AIRFLOW DISTRIBUTION AT DIFFERENT FLOOR LEVEL AT SMK BUKIT KATIL ACT AS A TEMPORARY EVACUATION CENTRE

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (REFRIGERATION AND AIR CONDITIONING SYSTEM) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this Choose an item. Entitled " Airflow Distribution At Different Floor Levels At SMK Bukit Katil Act As Temporary Evacuation Centre" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Mohamad Asyraf Aidee Bin Mohd Baseri

Date : 28/01/2022

APPROVAL

I hereby declare that I have checked this thesis, and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours.

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Date : 28/01/2022

DEDICATION

I would like to dedicate the success of this research to my parents, Mohd Baseri Bin Zakaria and Noor Wanee Binti Ab. Ghafar @ Mustapha. This report is dedicated to them because I want to express my gratitude for all their sacrifices for me throughout my time at this university. Second, this dedication is made to my siblings, who assisted me in completing this report through counsel, financial assistance, and encouragement. Following that, I'd like to offer my heartfelt appreciation to my supervisor, Ts. Dr. Amir Abdullah Bin Muhamad Damanhuri and my friends for their assistance in finishing this Final Year Project.

ABSTRACT

Natural disasters are often mentioned in Malaysia, and floods are one of the disasters that occur in our country every year. Due to this disaster, flood victims will be sent to evacuation centres to seek temporary shelter. Occupants in evacuation centres face various problems, including poor ventilation. Due to poor ventilation, the occupant quickly feels hot and uncomfortable while in the evacuation centre. A sampling of temperature and nature airflow velocity data is done at different floor levels every 30 minutes for 24 hours at SMK Bukit katil Melaka, Malaysia, used as a temporary evacuation centre. The data will be simulated in Ansys Workbench to get an airflow view consisting of two conditions: the classroom equipped with a tent and the classroom not fitted with a tent. The average air velocity and temperature result in the three floors is 0.47 m/s and 27.2 ° C for the ground floor, 0.64 m/s and 27.1 ° C for the first floor, and 1.33 m/s and 27.2 ° C for the second floor. And the simulation results from the Ansys Workbench software performed on all the floor levers showed the following readings: The average is 0.28 m/s (no tent) and 0.14 m/s (included tent) for the ground floor, 0.34 m/s (no tent) and 0.28 m/s (tent included) for the first floor, and 0.63 m/s (no tent) and 0.59 m /s (included tent) for the second floor. The study results found that the wind speed at each different floor level is different. And the results of the simulations on the three floors showed a slower wind speed after using the tent. This study can help the social welfare department provide a more comfortable evacuation centre. Level selection and installation of the tent at the correct floor level will help the victim achieve thermal comfort in natural ventilation.

ABSTRAK

Bencana alam sering menjadi sebutan di Malaysia, dan banjir merupakan salah satu bencana yang berlaku di negara ini setiap tahun. Disebabkan bencana ini, mangsa banjir akan dihantar ke pusat pemindahan untuk mendapatkan perlindungan sementara. Penghuni di pusat pemindahan menghadapi pelbagai masalah termasuk pengudaraan yang lemah. Penghuni pusat permindahan sementara cepat berasa panas dan tidak selesa semasa berada di sana. Persampelan data halaju angin semula jadi dan suhu pusat permindahan banjir dilakukan di 3 aras yang berbeza selama 24 jam dan selang waktunya adalah 30 minit di SMK Bukit katil, Melaka yang beroperasi sebagai pusat pemindahan sementara. Data tersebut akan disimulasikan dalam Ansys Workbench untuk mendapatkan pergerakan aliran udara yang terdiri daripada dua keadaan: Bilik darjah yang dilengkapi dengan khemah dan bilik darjah tidak dilengkapi dengan khemah. Hasil purata halaju angin dan suhu di tiga tingkat yang berbeza ialah: 0.47 m/s dan 27.2 ° C untuk tingkat bawah, 0.64 m/s dan 27.1 ° C untuk tingkat satu, 1.33 m/s dan 27.2 ° C untuk tingkat dua. Dan hasil simulasi daripada perisian Ansys Workbench yang dilakukan pada semua tingkat yang berbeza menunjukkan bacaan seperti berikut: Purata halaju angin adalah 0.28 m/s (tiada khemah) dan 0.14 m/s (termasuk khemah) untuk tingkat bawah, 0.34 m/s (tiada khemah) dan 0.28 m/s (termasuk khemah) untuk tingkat satu, dan 0.63 m/s (tiada khemah) dan 0.59 m/s (termasuk khemah) untuk tingkat dua. Hasil kajian mendapati kelajuan angin pada setiap aras adalah berbeza. Dan hasil simulasi yang dilakukan di tiga tingkat tersebut menunjukkan kelajuan angin lebih perlahan selepas menggunakan khemah. Kajian ini sedikit sebanyak dapat membantu pihak jabatan kebajikan masyarakat (JKM) menyediakan pusat pemindahan yang lebih selesa. Pemilihan aras dan pemasangan khemah pada aras yang betul akan membantu mangsa mencapai keselesaan terma dari segi pengudaraan semula jadi.

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In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to express my heartfelt gratitude to Allah the Almighty for his assistance and guidance during my life and at the moment of fact. I successfully finished my final year project study at University Technology Malaysia's Faculty of Mechanical and Manufacturing Engineering Technology (UTeM). At this time, I would like to express my appreciation to all parties involved, especially Ts. Dr. Amir Abdullah Bin Muhamad Damanhuri, the supervisor of the final year project, for providing me with the opportunity to complete the final year report project.

There are many lessons I can learn when doing this final year study. Finally, I'd like to thank my parents for their encouragement and belief in my ability to complete my Final Year Project Thesis. I'd like to thank everybody once again. Both of their kindness and generosity to me will be honoured till the end of time. Thank you so much.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
CFD	-	Computational Fluid Dynamics
PM	-	Particulate matter
SO_2	-	Sulfur dioxide
NOx	-	Nitrogen oxide
VOCs	-	Volatile organic compounds
VVOCs	-	Very volatile organic compounds
ASHRAE	-	American Society of Heating, Refrigerating and Air-Conditioning Engineers
HVAC	-	Heating, ventilation, and air conditioning
CO_2	-	Carbon dioxide
IAQ	-	Indoor air quality
DOSH	-	Department of Occupational Safety and Health
W1	-	Window 1
W2	-	Window 2
W3	-	Window 3
W4	-	Window 4
D1	-	Door 1
D2	-	Door 2
SMK	-	Sekolah Menengah Kebangsaan

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CHAPTER 1

INTRODUCTION

1.1 Background

At the end of 2014, peninsular Malaysia was devastated by one of the biggest flood catastrophes in the country's history, affecting Kelantan, Terengganu, Pahang, and Johor. According to the National Calamity Management Agency or NADMA, the flood occurrence in Kelantan in December 2014, described as a "tsunami-like disaster", was the most demanding and significant flood among the impacted states (Su-Lyn, 2015). Two hundred two thousand flood victims were relocated to various evacuation centres across ten districts (PAM, 2015).

The flood has caused infrastructure damage estimated at RM 2.9 billion. As part of the 2015 budget revision, the government committed about RM 8.9 billion for flood recovery operations on the east coast, including rehabilitation operations and welfare programs for flood victims and repairs and restoration of fundamental infrastructure (Akasah & Doraisamy, 2015). As a result, floods have posed several physical, environmental, and economic issues to society, the government, and the built environment.

Choosing public locations to serve as evacuation centres is critical during the disaster preparations and response stages (Bashawri et al., 2014). Public schools and community halls that serve as temporary shelters are naturally existing facilities created for their purposes but are forced to serve as shelters during a disaster's emergency phase. Malaysia National Directive No. 20. The administration expresses its desire to offer flood victims a safe and healthy living environment at the evacuation centres. While most evacuation centres now meet the demands of victims, a large number of them require space adjustments and structural renovations to endure future calamities (PAM, 2015).

At the evacuation centres, before the flood disaster in Kelantan 2014, the evacuation centre was inhabited by residents without using tents in the evacuation centres. All families are gathered in one place used as an evacuation, such as a classroom or hall. After the major floods in Kelantan, the government realized the importance of using tents in the evacuation area to protect the privacy of each family (Jabatan Kebajikan Masyarakat). Here arises the problem related to thermal comfort. One of the problems is poor airflow, causing people in the tent to feel hot and uncomfortable. This is because poor ventilation and stuff inside the evacuation centre are not correct, causing this problem (Jamaludin et al., 2015). This thesis aims to study using the actual area of the evacuation centres to be simulated in Ansys Workbench software. In this study, Ansys Workbench software solved problems related to ventilation. This study can help parties related to flood management, such as NADMA, the Department of Community Welfare (JKM).

1.2 Problem Statement

If the evacuation centre becomes overcrowded, the heat generated within the facility will become an issue. Several sources cause occupants in buildings to feel hot. Among the source is human body temperature. The body's temperature is maintained at 37 °C. The room's temperature might be raised a few degrees by combining body temperatures (Britannica, 2017).

Inadequate ventilation also contributes to heat in a place. By Tancrède 1987, residents of the evacuation facility would suffer due to the lack of moving air (Tancrède et al., 1987). Uncomfortable conditions and excessive heat in the facility were the most often reported issues, accounting for 48.3 % of all complaints. The incidence of conflicts at evacuation centres is also due to this factor (Said et al., 2013).

Because the hot outside air causes the inside of the structure to grow heated, the building's inhabitants are constantly confronted with increasing heat within the building (Shittu, 2015). All these problems will cause people around to be uncomfortable, and this study covers natural airflow that can address all of the issues above.

1.3 Research Objective

This research aims to improve airflow at an evacuation centre in a tropical climate region. Specifically, the objectives are as follows:

i. To monitor three different floors at SMK Bukit Katil, Melaka, Malaysia, act as a temporary evacuation centre.

ii. To simulate airflow distribution in 3 different floors in the evacuation centre at SMK Bukit Katil, Melaka, Malaysia, act as a temporary evacuation centre.

1.4 Scope of Research

The scope of this research are as follows:

i. Software SolidWorks 2016 to create a 3d building simulation drawing.

ii. Software Ansys Workbench student 2021 R2 created airflow simulations in the evacuation centre.

iii. This study is focused on the SMK Bukit Katil, which act as an evacuation centre in Melaka, Malaysia.

iv. The study was only on the ground floor, first floor, and second floor of the school building

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are study workings in the section that should be handled with this section. Literature reviews were required to collect the knowledge or data needed to validate this study of the airflow distribution in evacuation centres. First is research about floods in Malaysia and focus more detail on Melaka. Also stated in this chapter are evacuation centres, thermal comfort, poor distribution, indoor air quality, natural ventilation in the building, distribution parameters, and the last is research about previous Simulations using CFD software.

2.2 Floods in Malaysia

Any high water flow that dominates the natural or manmade banks in any area of the river system is referred to as a flood. As a result, when a riverbank is overtopped, the water extends over the flood plain, posing a threat to society (OSMAN, 2017). Floods have devastating consequences for people because they disturb their daily routines, and the effects might last up to a week. Climate change is projected to make the situation much more difficult (Chan et al., 2015).

Flooding is a natural occurrence that can't be avoided or minimized no matter how much a government or community tries (Hamzah et al., 2012). Flood is the most destructive natural calamity Malaysia has ever seen. There are 189 river basins in

Malaysia, including Sabah and Sarawak, with primary flows running straight to the South China Sea, and 85 of them are prone to frequent floods (89 of the river basins are in Peninsula Malaysia, 78 in Sabah, and 22 in Sarawak). The projected area vulnerable to flood catastrophe is around 29,800 km^2 or 9% of Malaysia's total territory, and it affects almost 4.82 million people, or about 22% of the country's entire population (N.W Chang, 2000).

The Malaysian Drainage and Irrigation Department categorizes floods in Malaysia into two types, flash floods and monsoon floods (D/iya et al., 2014). The time it takes for the river flow to return to normal levels is the evident difference between these two disasters from a hydrological standpoint. Monsoon floods can linger for a month, whereas flash floods take only a few hours to restore normal water levels (Noorazuan, 2006). The rainfall pattern in Malaysia is seen in Figure 2.1 and how it is impacted by the two monsoons, the southwest and northeast monsoons. Malaysia is split into two parts, West Malaysia (Peninsula Malaysia) and East Malaysia (Sabah and Sarawak), which the South China Sea separates (D/iya et al., 2014). Figure 2.1 shows Southwest and Northeast monsoons.

Figure 2.1Direction shows the Southwest and Northeast monsoons. Source:(D/iya et al., 2014)

Local weather fluctuations are one of the natural causes of flash floods however, non-natural reasons such as an ineffective urban drainage system and an increase in the number of buildings in urban areas are the leading causes of flash floods in the Klang Valley Peninsular (Akasah & Doraisamy, 2015). According to Chan (2000), the danger and vulnerability of urban people to floods have lately grown due to an increase in impervious surfaces such as roads, buildings, and parking spaces. In addition, floods have been seen to have a more significant economic impact on low-income residents, particularly those living in flood-prone areas (Chan, 2000). With their meagre income, they can only make a little effort to alleviate the effects of floods (Hamzah et al., 2012). Since the 1920s, Malaysia has been hit by a succession of floods, the most recent of which occurred in December 2006 and January 2007. As a result of these floods, the rescue and recovery agencies have gained valuable expertise.

2.2.1 Floods in Melaka

The selected area for this study is Melaka. It is one of the states in Malaysia that experiences flood annually. It has three main districts namely Alor Gajah, Melaka Tengah and Jasin. Most of the tourist attractions are located in Melaka Tengah District. Figure 2.2 shows the location of the districts in Melaka. Melaka has been chosen as the study's location. It is one of the Malaysian states that are prone to flooding. It is divided into three districts Alor Gajah, Melaka Tengah, and Jasin. Melaka Tengah District is home to the majority of tourism attractions.

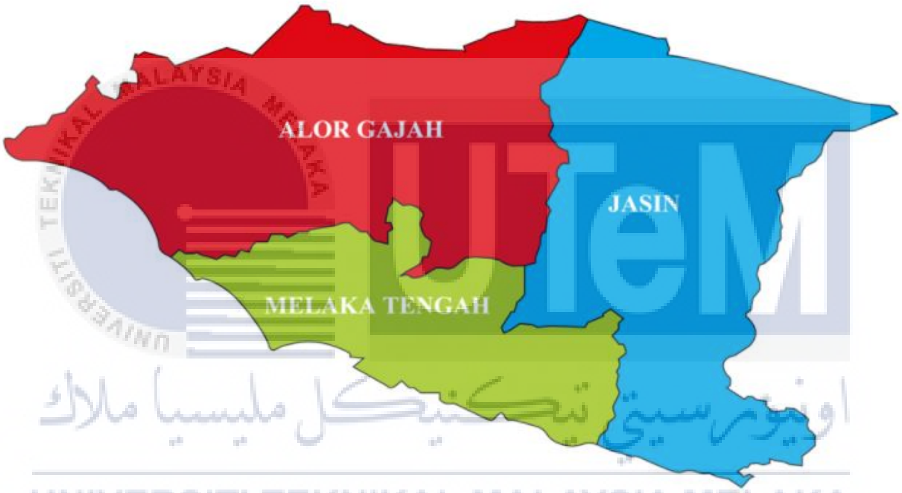


Figure 2.2Melaka's districts. Source: (*PLANMalaysia@Melaka*, n.d.)

In 2021, after the accident affected over 2,500 persons, more than 20 temporary evacuation facilities were created in Melaka till January 3, 2022. According to the Director of the Malaysian Civil Defense Force (APM) Melaka, a total of 656 households have been affected across the state of Melaka. Melaka Tengah district had the largest victims, with 1,391 victims spread over nine housing areas. Ten evacuation centres were opened in the Alor Gajah region on December 31, 2021. A total of 1,015 victims were evacuated until January 3, 2022, with the Durian Tunggal area among the most badly hit. In Melaka

Tengah, the evacuation centres at SK Krubong and SK Batu Berendam 2 reported the highest victims, with over 300 victims each. In addition, a temporary evacuation centre was established after nine places were damaged, including Kampung Parit Penghulu Benteng. Kampung Lanchang, The tragedy devastated the villages of Tersusun Rambai Jaya, Tasek, and Chinchin. Aside from that, the calamity also impacted inhabitants in the Chohong and Chenderah districts. The Alor Gajah district is impacted in the following areas, Kampung Gadek Dalam, Taman Seri Bayu 1 and 2, Pengkalan and Kampung Panchor, Kampung Beringin, Kampung Sungai Siput, Lubok Cina, Kampung Belimbing, Kampung Jeram, Kampung Pulau, and Kampung Telok Berembang. While in Melaka Tengah, it is in the villages of Lanjut Manis, Padang Siapong, Tanah Merah, and Krubong.(Shuhada Abdul Kadir, 2022).

Flooding in Melaka can be caused by one of two factors. First, there was a protracted period of heavy and high-volume rain. While Melaka is typically located in the lowland sections of the Peninsular, it has two water dams for the primary objectives of water retention and household supply. The bordering territories of the neighbouring states, on the other hand, are mainly hilly places along the backbone of Malaysia's peninsular, known as Banjaran Titiwangsa. Water comes into the Alor Gajah area from the state's south. This area has several villages, new neighbourhoods, and small townships constantly emerging. Second, the tremendous tidal surge from the straits into the Melaka River and its tributaries, where these communities are located, may occur at irregular intervals. When these two events coincide, Jus and Durian Tunggal dams rarely flood (Mohamad et al., 2021). Figure 2.3 show Melaka's high flood risk areas.

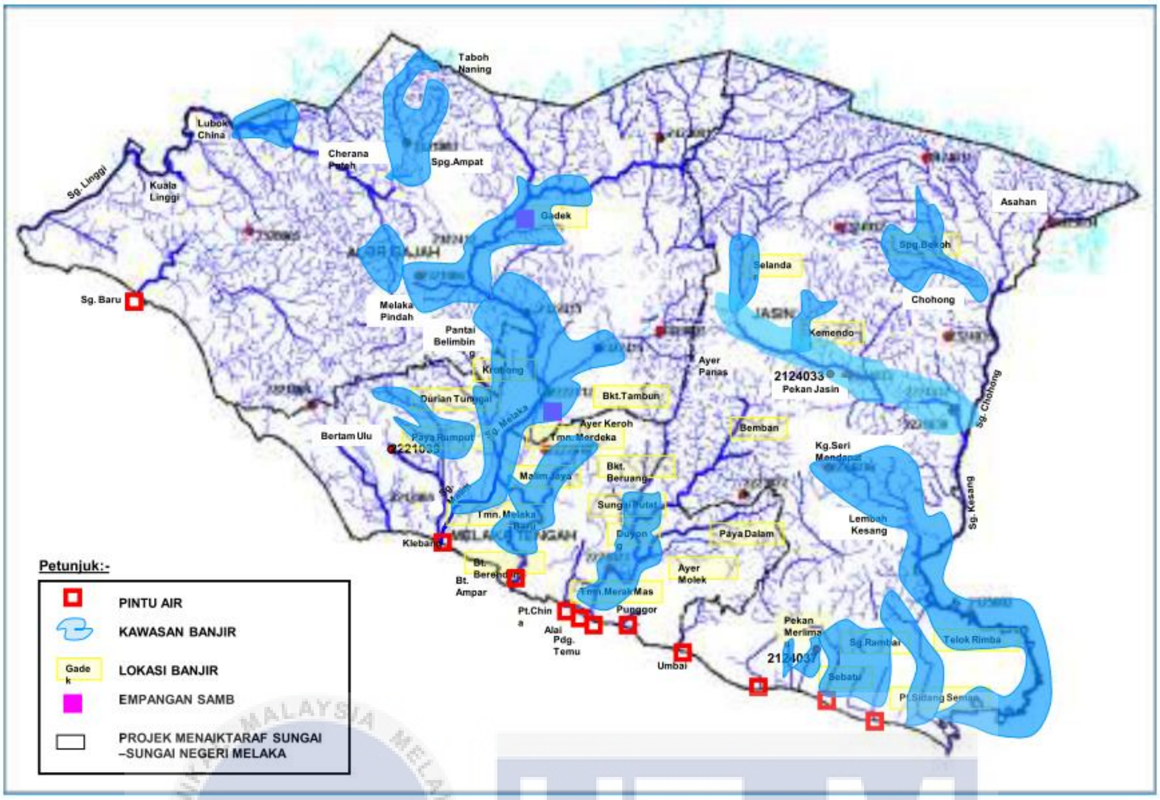


Figure 2.3Map of high flood risk areas in Alor Gajah district.

Source: (Mohamad et al., 2021)

2.3 Evacuation centres

Evacuation centres are designated as safe havens for displaced persons due to specific situations, such as catastrophes (natural hazards such as flood, hurricane, and fire, where people have to leave their own homes due to its risks). Evacuation facilities are designed to handle people who have been exposed to such dangers (Hashim et al., 2016).

Malaysia has been hit by a series of significant floods in the recent decade. Natural and human forces caused flooding. Malaysians are a riverside people by nature, as their early dwelling areas evolved along the banks of the peninsula's major rivers. Floods have become the norm for many Malaysians because of natural reasons such as excessive monsoon rainfall, severe convective rainstorms, inadequate drainage, and other local variables (Chan et al., 2015).

Melaka's state government has identified 46 flood-prone sites across the state's three districts, and preparedness steps have been implemented to deal with the tragedy in the future. Melaka Tengah and Jasin districts have 15 areas, whereas Alor Gajah has 16 areas. In addition, 92 temporary evacuation centres have been found, with a capacity of nearly 26,000 victims (Bernama, 2019).

Some of the places where research can be done for this thesis are classrooms in schools shown in Figure 2,4, multipurpose halls are shown in Figure 2.5, and public halls are shown in Figure 2.6. And Table 2.1 shows the list of evacuation centres in Melaka Tengah.

Figure 2.4Classroom at school. Source: (Chik, 2016)

Figure 2.5Multipurpose hall. Source: (jiji, 2020)

Figure 2.6Public halls. Source: (Asrol awang, 2020)

Table 2.1 List of evacuation center in Melaka Tengah. Source: (Jabatan Kebajikan Masyarakat)

No	Zone	Evacuation centre	Latitude	Longitude	Capacity
1	Dun Kota Laksamana	SJK(C) Notre Dame	2.207292	102.241472	200
2	Dun Kota Laksamana	Sek. Ke. Bukit Cina	2.203547	102.256462	200
3	Dun Kota Laksamana	Balai Raya (Bilik Bacaan) Kg Chetti	2.200567	102.238427	30
4	Dun Kesidang	Sek. Men. Gajah Berang	2.202811	102.240864	400
5	Dun Kesidang	Sek. Men. Katholik	2.206764	102.241449	400
6	Dun Kesidang	Sek. Men. Notre Dame Convent	2.207537	102.242444	400
7	Dun Kesidang	Sek. Keb. Methodisc (ACS) Kesidang	2.204937	102.236442	200
8	Dun Kesidang	Sek. Keb. (P) Methodist 1	2.204265	102.233924	200
9	Dun Kesidang	Sek. Keb. (P) Methodist 2	2.204265	102.233844	200
10	Dun Kesidang	Sek. Ren. Jenis Keb. Tengkera 1	2.203678	102.232202	150
11	Dun Kesidang	Sek. Keb. Limbongan	2.208581	102.220463	150
12	Dun Kesidang	SK Taman Merdeka	2.270917	102.236571	800
13	Dun Kesidang	SJK(C) Malim, Melaka	2.237005	102.224989	300
14	Dun Banda Hilir	Balai Raya Kampung Bukit Cina	2.307923	102.172604	80

2.4 Thermal Comfort and Health

Thermal comfort in dwellings is determined by three factors, temperature, air movement, and humidity. The temperature affects air quality and can cause a lot of pain. The thermal feeling is a powerful motivator, and it may induce the occupant to act in incompatible ways with the ventilation system's initial design requirements. Sick Building Syndrome is more likely when the interior temperature is high (SBS) symptoms (Avgelis

& Papadopoulos, 2004). Indoor temperature and humidity may be controlled through ventilation. When ventilating a building, both interior air quality and temperature are taken into account. When constructing ventilation systems, air movement is also a significant factor to consider.

The occupants have control over the airflow and the pace at which the HVAC blows in the air. If the occupants are already comfortable or cold, high-velocity, even turbulent indoor air circulation might create discomfort from draughts. If the temperature is more significant and the occupants are overheated, too little air movement will not fix the problem, and more air movement may be beneficial (Avgelis & Papadopoulos, 2004). Finally, indoor humidity impacts comfort, and it may need to be raised or decreased depending on the weather and the inhabitants. When outside air is used for ventilation, very low interior humidity might develop in cold weather, resulting in dryness and nasal and ocular discomfort. Furthermore, high relative humidity can occur in hot weather, reducing the capacity to dissipate heat by evaporative mechanisms (sweating) and increasing the pain associated with overheating. Dust mites, allergens, and mold, which cause asthma and other allergic illnesses, are also more prevalent.

2.5 Effect poor distribution

Many effects if poor distribution in the evacuation centre area. In terms of comfort and also in terms of health. This is because the poor distribution will accumulate pollution in the area we live in now. Here are some of the effects of the lack of flow at the evacuation centre.

2.5.1 Indoor Air Contaminants

Indoor air pollution refers to dust, filth, or gases in the air within structures, such as houses or offices, that are potentially unhealthy to breathe. Lung disorders including asthma, COPD, and lung cancer have been related to poor indoor air quality. It's been related to an increased risk of heart disease and stroke, as well. Here describe some types of effects if the evacuation centre poor distribution. Table 2.2 shows the sources and types of Indoor Air Pollution caused by several sources.

Table 2.2 Indoor air pollution sources and types. Source: (R. K. Crump et al., 2009)

Source	Main pollutants
Outdoor air	SO_2, NOx, ozone, particulates matters, biological particulates, benzene
Combustion of fuel	CO, NOx, VOCs, particulates matters
Tobacco smoke	CO, VOCs, particulates matters
People	CO_2, organic compounds
Building materials	VOCs, formaldehyde, radon, fibres, other particulates, ammonia
Consumer products	VOCs, formaldehyde, pesticides
Furnishings	VOCs, formaldehyde
Office equipment, including HVAC	VOCs, ozone, particulates
Bacteria and fungi	VOCs, biological particulates
Contaminated land	Methane, VOCs, contaminated dust, e.g., metals
Ground	Radon, moisture
Washing and cleaning	Moisture
Animals (e.g. mites, cats)	Allergens

Crump (2009) defines and list a variety of indoor pollutants. The following are some of them (R. K. Crump et al., 2009). Construction and furnishing materials release volatile organic compounds (VOCs) over weeks or years, degrading air quality. The release of VOCs from consumer electronics, such as computers and printers, and cleaning products and air fresheners is attracting attention. ETS is made up of a complex blend of organic compounds. Although smoking is prohibited in many workplaces and public facilities, it is a significant source of air pollution in many households (ASHRAE, 2009).

Because of its release from various construction and consumer goods, formaldehyde is a very volatile organic compound (VVOC) that has been extensively examined. Semi-volatile organic compounds (SVOCs) have a lower vapour pressure than more volatile VOCs, but they appear to be found at lower concentrations in indoor air. Plasticizers used in polymeric products like vinyl flooring and paints, pesticides like DDT and pentachlorophenol, and polycyclic aromatic hydrocarbons (PAHs) formed during fuel combustion and are found in coal tar. Tobacco smoke is just a few examples (Alrazni, 2016).

CO_2 is a common air component, and it is only in some instances that it is found in large concentrations to pose a health risk. It can be found in buildings due to human and animal respiration, as a combustion agent, and as a part of soil gas. It's commonly used as a measure of ventilation rate and, in some cases, as a proxy for body odour. CO_2 is a colourless, odourless gas created when most fuels are burned inefficiently. Where there is insufficient ventilation to an appliance, for example, incomplete combustion may occur. Gas-fueled cookers, flames, water heaters, and oil-fired space heaters all release nitrogen dioxide (NO_2) (Alrazni, 2016).

Sulfur dioxide (SO_2) is emitted when sulfur-containing fuels, including coal and oil, are burned. Ozone is a pollutant of the atmospheric air that is produced by a photochemical reaction. It reacts with surfaces and airborne contaminants to create new organic compounds and particles within the home. People develop water vapour through tasks like cooking, cleaning, washing, and natural breathing. The volume of water vapour in the environment significantly impacts health and comfort and is essential in biological contaminants (Alrazni, 2016).

Particle pollution is a term used to describe a mixture of tiny solid and liquid particles present in the air, both indoors and out, that can harm one's health. Since the particles themselves are varying sizes, others are one-tenth the diameter of a strand of hair, assessing particle emission is difficult. Many are much smaller, and others are so rare that only an electron microscope will see them. Specific particles are invisible due to their small size, but together they emerge as a cloud, which forms as millions of particles blur the distribution of sunlight. This suggests that people are unaware when objects are inhaled, although it is so harmful that it will shorten life. Natural antibodies assist us in coughing or sneezing bigger particles out of our bodies. Still, they do not drive out tiny particles (those smaller than 10 microns in diameter, or about one-seventh the diameter of a single human hair). These particles get stuck in the lungs, while the tiniest will slip through the lungs and into the bloodstream (Al-Salem & Khan, 2010).

Particles are divided into three sizes by researchers: coarse, refined, and ultrafine. PM10-2.5 particles are coarse particles with a diameter of 2.5 microns to 10 microns. PM2.5 refers to fine particles with a diameter of 2.5 microns or less. Ultrafine particles have fewer than 0.1 microns and are small enough to move across lung tissue and into the bloodstream, where they circulate alongside oxygen molecules. Particles of any size can be detrimental to one's body, while smaller particles can reach further into the organs (Al-Salem & Khan, 2010)

i. PM0.1 – particulates with a diameter of fewer than 0.1 microns (100 nm).

ii. PM10 – Particulates with a diameter of fewer than 10 microns.

iii. PM2.5 – Particles with a diameter of fewer than 2.5 microns are referred to as microparticles.

Particle types and chemical or biological elements such as bacteria and viruses are shown in Figure 2.7 below.

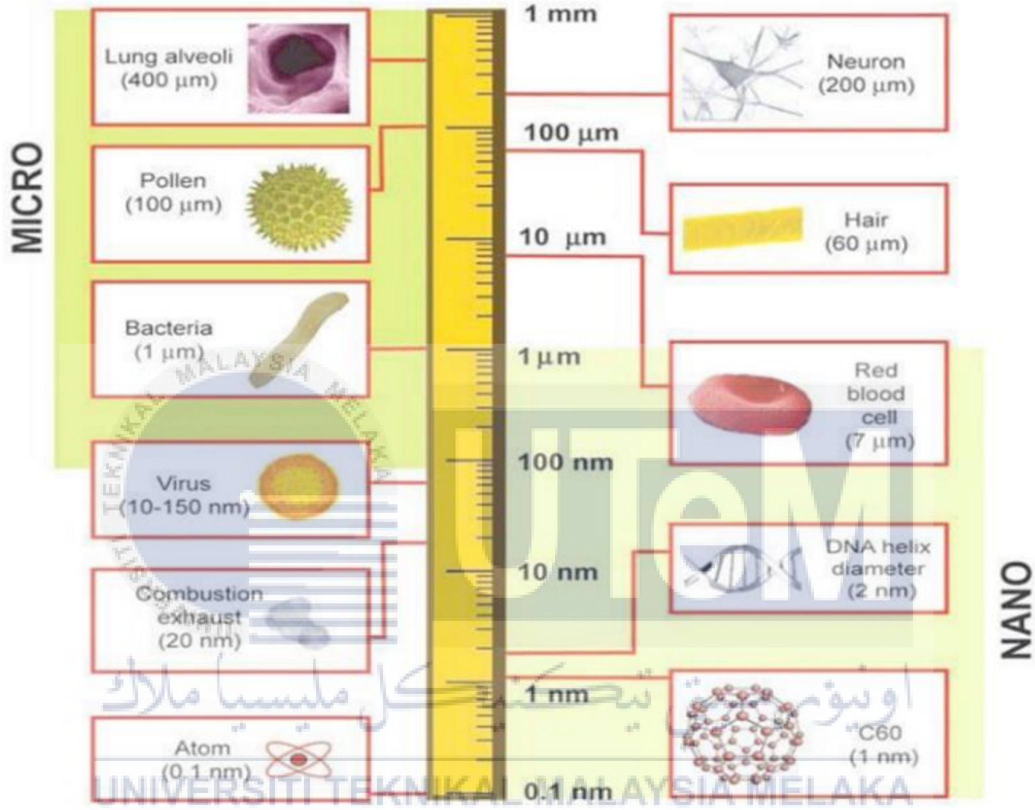


Figure 2.7On a logarithmic length scale, the size of nanomaterials in comparison to biological components; definitions of 'nano' and 'micro' scales. Source: (Buzea et al., 2007)

Recent epidemiological studies have discovered a close link between levels of particulate air pollution, respiratory and cardiovascular disorders, tumours, and mortality. (Buzea et al., 2007). There have been several research experiments and analyses on the causes of indoor emissions (Bruinen de Bruin et al., 2008; Chang et al., 2007; J. A. Crump et al., 2004; Meininghaus et al., 1999; Morawska & Salthammer, 2003; Oliveira et al., n.d.; Silvie et al., 2004; Zwart et al., 2002), since most people spend most of their time indoors, the health consequences of being exposed to both outdoor and indoor contaminants may be necessary. Any citizen in the UK has their life expectancy reduced by an average of 7-8 months due to air pollution, with annual health costs expected to be in the region of £20 billion (J. A. Crump et al., 2004). Bad IAQ is thought to be a significant cause or aggravating factor in the following diseases, according to WHO (2000a):

i. Symptoms of allergies and asthma
ii. Cancer of the lung
iii. COPD stands for chronic obstructive pulmonary disease (COPD)
iv. Respiratory illnesses spread by the air
v. Cardiovascular disease is a condition that affects the heart and blood vessels (CVD)
vi. Irritation and odour (SBS symptoms)
vii. Anxiety

Indoor air pollution has a wide range of health consequences, based on the types of pollution present, the concentration of each pollutant, and the individual's relative vulnerability. Acute effects include asthma, hypersensitivity pneumonitis, and headaches. Chronic products include cancer, coronary attack and, COPD, which is Chronic Obstructive Pulmonary Disease (Jiang et al., 2016).

2.6 Indoor air quality (IAQ)

“Indoor Air Quality (IAQ) refers to the air quality inside and around buildings and infrastructure, particularly when it relates to the health and comfort of building occupants,” according to the United States Environmental Protection Agency (Cashman et al., 2016). Indoor air can be much more polluted than outdoor air, contrary to common opinion. Most people associate air pollution with something outside the home: smog, ozone, smoke in the air, or a noxious odour from a local chemical plant. However, the air inside houses, offices and other structures can be far more toxic than outside (Davis, Karen; Wilson, 1992). Lead (in-house dust), formaldehyde, fire retardants, radon, microscopic dust mites from moulds, and even volatile chemicals from fragrances used in conventional cleaners are also common contaminants found in the environment within houses. Any pollutants are tracked into the home by a new mattress or furniture, carpet cleaners, or a coat of paint on the walls, according to (Davis, Karen; Wilson, 1992).

One of the top five pollution threats is poor indoor air quality (IAQ) (Cashman et al., 2016). Improving indoor air quality in buildings may have a significant impact on occupant health. Pollutants in the air of a building can induce dizziness, headaches and aggravate allergies and asthma. Although sweeping and vacuuming will help improve indoor air quality, they will not fix IAQ issues independently. Good indoor air quality has a slew of advantages. It improves employee well-being, satisfaction, and occupant morale, reduces absenteeism, enhances learning and student success, and provides a more supportive customer experience (Lennox, 2016). Advantages of an Increased decent return on investment (ROI) and bottom-line economics have also been linked to IAQ (ASHRAE, 2009). While the problems associated with poor IAQ have been well reported and are widely accessible, building design and development decisions are often taken without considering the potentially dangerous effects of poor IAQ. Ventilation has been a significant construction element for as long as man has been systematically designing his house. Public consciousness and concern about indoor air quality (IAQ) have gradually grown in the last century. It is now a significant consideration in the design and construction of any habitable building. “In most cases, IAQ is still not a high-priority architecture or building management issue compared to purpose, expense, space, aesthetics, and other attributes such as location and parking," according to (ASHRAE, 2009).

2.6.1 The Physical Parameters

The parameters shown in Table 2.3 are the physical characteristics of IAQ, and their acceptable range is listed. To have a healthy IAQ, various factors allow for a broad range of proper conditions.

Table 2.3 Physical Parameters. Source: (DOSH, 2010)

Parameters	Acceptable Range
Air temperature	(23 to 26) ℃
Relative humidity	(40 to 70) %
Air movement	(0.15 to 0.50) ms

2.7 Natural ventilation in the building

While fan-forced ventilation relies on pushing air through buildings using mechanical devices, natural ventilation utilizes natural forces such as wind and buoyancy to provide fresh air. In buildings, fresh air is essential to eliminate smells, supply oxygen for breathing, and improve thermal comfort.

2.7.1 Natural ventilation mechanism

Dynamic and static pressure differences are natural ventilation driving forces. As a consequence, more significant pressure differences result in a faster rate of ventilation. The active pressure differential is caused by the wave, while the static pressure difference is caused by the temperature gradient, also known as buoyancy or stack effect. A variation of static and dynamic pressure fluctuations can also drive natural ventilation (British Standards Institution, 1980).

When wind strikes a house, it creates a pressure difference on the windward side, with positive pressure on the windward side and negative pressure on the leeward side and sidewalls, shown in Figure 2.8. Having holes in the external walls allows external air to flow from the positive pressure zone to negative pressure across the interior spaces (Linden, 1999). A more significant pressure differential leads to a higher degree of indoor airflow. The pressure distribution on the building façade is affected by building shape, wind speed, wind direction, and the surrounding atmosphere (Hunt & Linden, 2001; Linden, 1999).

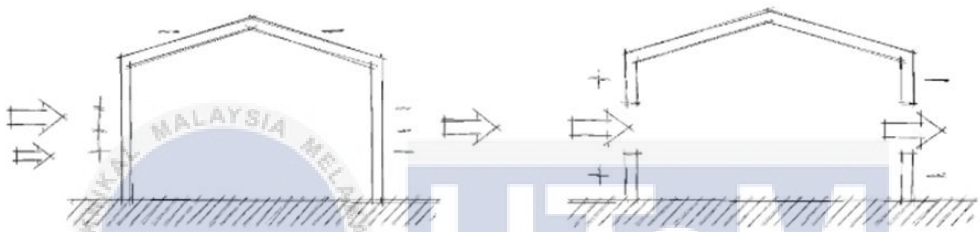


Figure 2.8The wind shows there are positive and negative pressure zones. Source: (Omrani, 2018)

The air density is affected by temperature differences, which causes buoyancy forces that propel the air from high-density (lower temperature) to low-density (higher temperature) areas (higher temperature). There are two types of buoyancy-driven ventilation, combining ventilation and displacement ventilation (Linden et al., 1990). Mixing ventilation is described by a single opening that serves as both a source and an exhaust. Excellent air enters the enclosure from the lower part, and warm air escapes from the upper part. On the other hand, displacement ventilation uses two openings at opposite heights, with cold air coming in through the lower opening and warm air leaving through the higher opening, usually above the ceiling, as shown in Figure 2.9 (Linden & Cooper, 1996).

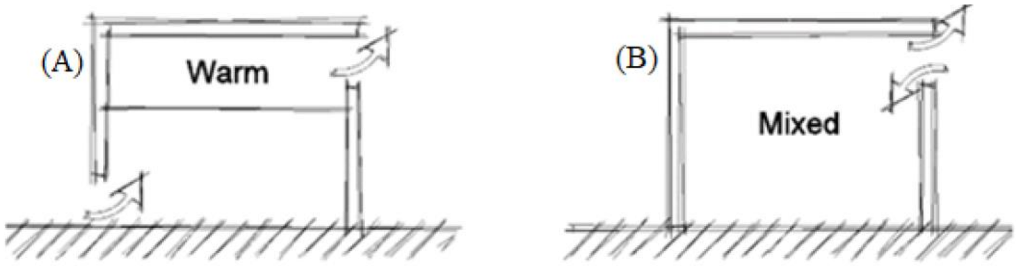


Figure 2.9 Ventilation driven by buoyancy: (A) displacement ventilation and (B) mixing ventilation. Source: (Omrani, 2018)

A combination of wind power and stack effect can also drive natural ventilation. Dependent on the position of openings and the direction of the incident wind, these forces can counteract or complement each other (Hunt & Linden, 2001). The stack effect and buoyancy forces are caused by temperature variations within and outside spaces with gaps at varying heights. As seen in Figure 2.10, the pressure difference produced by wind forces will strengthen Figure 2.10 (A) or oppose Figure 2.10 (B) the buoyancy forces, depending on the incident wind direction.

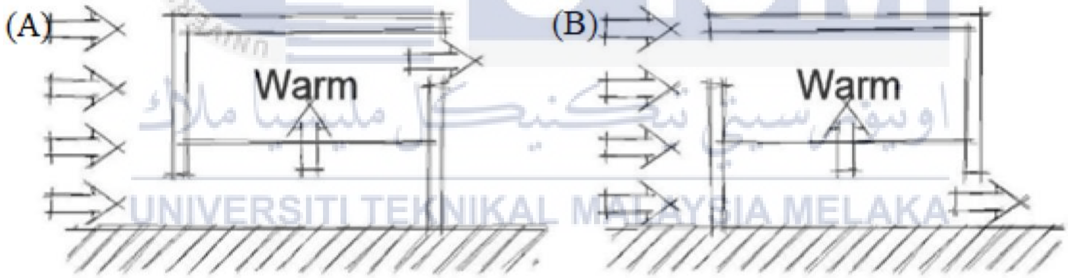


Figure 2.10 The combined forces of wind and buoyancy complement (A) and oppose (B). Source: (Omrani, 2018)

Wind-driven ventilation is much more efficient than stack ventilation, but stack ventilation has the advantage of being able to disperse air in a room even though there is no wind (Walker & Devine-Wright, 2008).

2.7.2 Advantage and disadvantage

Natural ventilation has many benefits, including reduced energy usage and pollution, improved thermal comfort, improved indoor air quality, and low initial and ongoing costs. Natural ventilation is one of the most critical factors affecting indoor thermal comfort, especially in cool climates (Papakonstantinou et al., 2000). An increased air velocity will remove the human body's surplus heat and provide a thermally stable environment. Indoor thermal temperatures that are uncomfortable promote air conditioners, resulting in increased energy consumption (ASHRAE, 2009).

Space conditioning consumes 30% of the electricity used in the construction industry (Liddament M., 1996). Natural ventilation uses natural mechanisms to replace hot air within a room with cold air from outside. As a result, natural ventilation can reduce energy demand and carbon emissions (Santamouris et al., 2001).

Furthermore, natural ventilation can improve indoor air quality by replacing the old air within the room with a new perspective from the outside (Santamouris et al., 2001). Improvements in indoor air quality develop the health and performance of residents (Fisk, 1997). Furthermore, according to a report on the impact of natural ventilation and mechanical ventilation on airborne infection transmission in hospitals, natural ventilation reduces the risk of airborne infection by 6-28 percent (Escombe et al., 2007). Natural ventilation is also much more cost-effective than mechanical ventilation in installation and upkeep, mainly residential buildings (Etheridge, 2011). Despite the benefits described above, there are some drawbacks to using natural ventilation in houses, such as reduced power, noise, and emissions from the outside.

Natural ventilation, unlike artificial ventilation, is heavily reliant on natural forces such as wind speed and direction (Bailey, 2000). As a result, in naturally ventilated houses, occupants cannot conveniently change the ventilation volume. As a result, overheating would be unavoidable in severe, hot climates some days (Etheridge, 2011). Furthermore, the reliance on building ventilation efficiency on wind conditions necessitates the careful analysis of building position and architecture to allow natural ventilation, contributing to the design challenges (Walker & Devine-Wright, 2008). Furthermore, the enclosure is susceptible to outside noise and emissions due to open windows used for natural ventilation (Kwon & Park, 2013), particularly in congested areas and near pollution sources.

Despite the drawbacks of natural ventilation in homes, this passive cooling mechanism is still a viable option for space cooling. In hot humid climates, where cooling is much essential, this becomes much more feasible. Furthermore, residential buildings with fewer inhabitants (when opposed to office and industrial buildings) and more wardrobe options have a greater chance of successfully implementing natural ventilation.

2.8 Distribution parameter

Natural ventilation in buildings is influenced by various factors, some outside the planners' control, such as exterior environmental conditions and site density, and others of which can be tackled by proper planning. These are referred to as "design-dependent criteria" in the current report and discussed in this section.

2.8.1 Natural ventilation modes

The ventilation mode has the most significant impact on design-related parameters that affect natural ventilation (Lee et al., 2014). The aperture placements and ventilation system can be used to describe the raw ventilation mode. As a result, natural ventilation can be categorized into three groups:

i. Single-Sided Ventilation

ii. Cross-Flow Ventilation

iii. Stack ventilation

As seen in Figure 2.11, single-sided ventilation happens as air enters and exits from one side of the room from one or more holes on the same side (Awbi, 1994). Since the air in single-sided ventilation enters and exits the enclosure from the same direction, it does not flow in the entire room.

Figure 2.11 Single-sided ventilation. Source: (Omrani, 2018)

Buoyancy forces, wind forces, or both will drive single-sided ventilation. Buoyancy forces are dominant when the wind speed is low (e.g., up to 2 m/s) and there is a temperature differential inside and outside. Wind forces take over at higher wind speeds, and buoyancy forces become insignificant (Allocca et al., 2003). Total flow rate is determined by the mean and pulsating components of wind in wind-driven single-sided ventilation, with pulsating flow dominating for small openings and mean flow dominating for large openings (Zhou et al., 2017). Cross-flow airflow happens when two or more openings are mounted on opposite walls, shown in Figure 2.12, with air flowing in from the windward side (inlet) and out of the opposite side (outlet) (Ohba & Lun, 2010). Wind velocity and the resulting pressure distribution around openings have a significant impact on cross ventilation. Cross-ventilation is much more efficient than single-sided ventilation (Awbi, 1994) since there is a more powerful pressure difference between the inlet and the outlet.

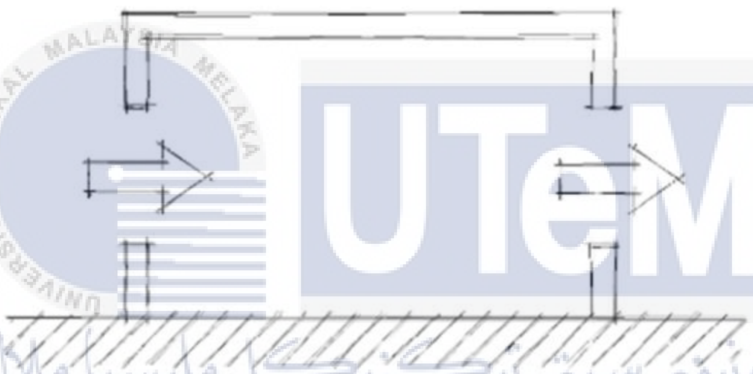


Figure 2.12 Cross ventilation. Source: (Omrani, 2018)

Suppose there is a height gap between the inlet and outlet shown in Figure 2.13, hot air rises and exits from the higher opening, replaced by cold air entering from the lower opening shown in Figure 2.13 (A) (Steven V. Szokolay, 2014). The height differential between the inlet and outlet determines how efficient stack ventilation is. As a result, stack ventilation works well in spaces with a high floor-to-ceiling height and where ventilation chimneys are used in Figure 2.13 (B).

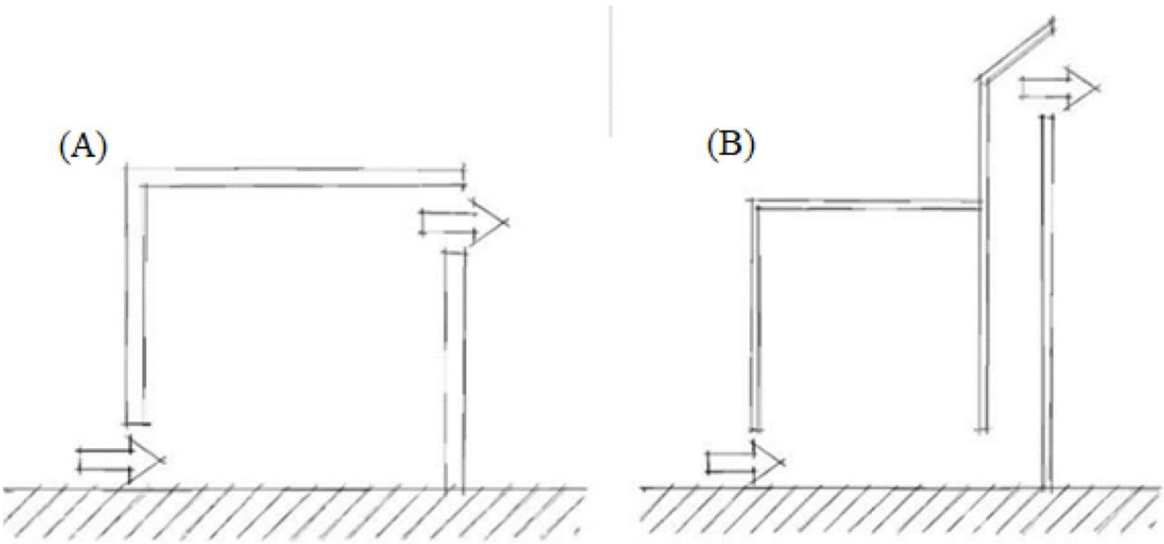


Figure 2.13 Stack ventilation in a space with openings (A) and stack ventilation with the use of ventilation chimney (B). Source: (Omrani, 2018)

2.8.2 Building height

The primary driving powers of natural ventilation (wind and buoyancy) are the same for low-rise and high-rise structures. The biggest problem with natural ventilation in high-rise buildings is the more significant pressure variations caused by wind and buoyancy resulting from the higher heights (Etheridge, 2011). The wind strength and friction both rise as the height of the building rises (Mehmet Halis Günel, 2014), resulting in a broader pressure spectrum across the facade of a house. The relationship between wind speed and height is depicted in Figure 2.14, which shows a diagram of the atmospheric boundary layer. As seen in this diagram, the wind pressure loading on a building varies significantly with height, with upper levels having higher wind pressure loads than lower levels. As a result, higher wind noise in upper high-rise buildings poses additional problems for natural ventilation architecture in opening size and design (Salib, 2013).

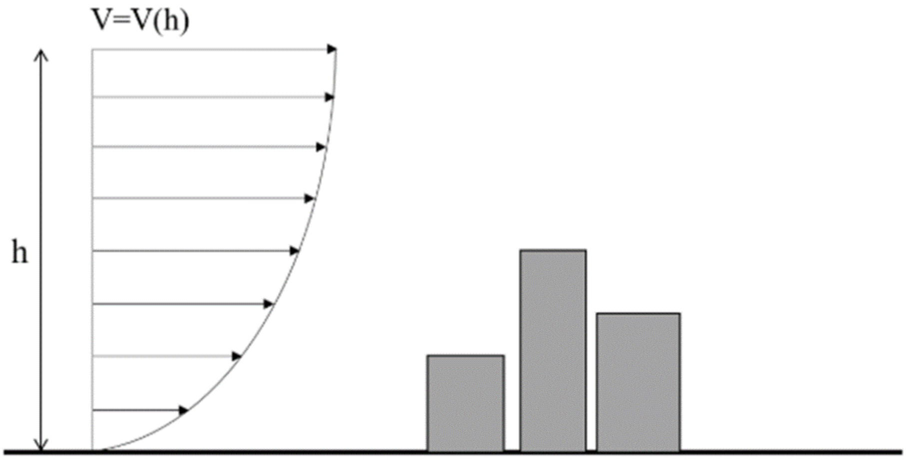


Figure 2.14 The profile of the atmosphere's boundary layer is shows in this diagram. Source: (Salib, 2013)

Buoyancy forces are developed with a temperature and height differential between the inlets and outlets (Salib, 2013). The room height is the primary determinant of buoyancy-driven pressure gaps in elevated floor-to-ceiling spaces and chimney-like structures (Etheridge, 2011). Identifies three types of natural ventilation strategies for tall buildings shown in Figure 2.15. The pressure differential created by buoyancy forces is not troublesome in type A shown in Figure 2.15 (A). The whole floor area is filled, and openings of each floor are not connected to vertical voids and will behave similarly to the buoyancy forces of low-rise buildings. The wind is usually the primary source of natural ventilation in this situation. This pressure differential becomes difficult in category B in Figure 2.15 (B) high-rise buildings with central voids and wide internal openings. In such cases, the house acts as a single-cell, and the relative height of the structures determines the pressure differential caused by buoyancy forces. As a result, the lower-level units suffer a significant pressure reduction, potentially resulting in an unacceptably high force threshold for opening the windows (Pei-Chun et al., 2012). Suggest segmentation in Figure 2.15 (C) to solve the undue pressure difference caused by buoyancy forces in buildings with central voids. Each section is isolated from the other segments in this process, similar to a low-rise house.

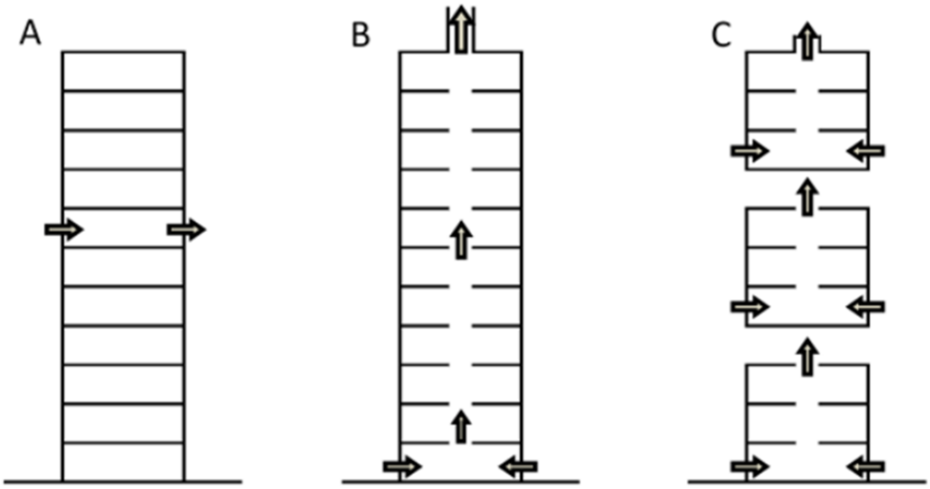


Figure 2.15 Tall building structures and ventilation techniques include (A) covering the whole level (isolation), (B) connecting floors with a central void and (C) segmentation. Source: (Etheridge, 2011)

2.8.3 Window and opening

One of the most researched aspects of architecture is the influence of openings on natural ventilation. Due to their shapes and forms, openings and their effect on natural ventilation have been investigated.

Opening configuration can relate to the openings' shape, size, and positioning of the façade (Lukkunaprasit & Ruangrassamee, 2009). According to research on the effect of opening arrangement on ventilation rate, positioning two openings opposite or perpendicular improves ventilation performance (Gao & Lee, 2011b). Another research was conducted (Hassan et al., 2007). Concerned with the layout of the apertures in single-sided ventilation, researchers found that placing two openings far apart enhances ventilation effectiveness compared to having two nearby gaps, which backs up

Santamouris and Allard's prior suggestions Yin (1998) (Wei Yin, Guoqiang Zhang, Wei Yang, 2010), Tantasavasdi et al. (Tantasavasdi et al., 2001), as well as (Derakhshan & Shaker, 2016), have just been published (Derakhshan & Shaker, 2016). For cross ventilation, we looked at the opening configuration. According to (Wei Yin, Guoqiang Zhang, Wei Yang, 2010), relative opening heights significantly impact ventilation performance. Their findings showed that having the same level of intake and output leads to more excellent ventilation in most circumstances. They were discovered by Tantasavasdi (2001) that a more significant intake with a smaller exit improves ventilation rate (Tantasavasdi et al., 2001), despite Santamouris and Allard's proposal in their design manual (Allard et al., 1998), which suggests an equal or more significant exit. According to Derakhshan & Shaker (2016), Rectangular windows with a decreased width-to-height ratio would provide better natural ventilation(Derakhshan & Shaker, 2016).

Several research studies have looked at the different types of openings and their effects on interior airflow and natural ventilation (Gao & Lee, 2011b; Heiselberg et al., 2001; O'Sullivan & Kolokotroni, 2017; von Grabe et al., 2014; Wang et al., 2015).

For single-sided and cross ventilation modes, the impact of various opening styles was evaluated (Gao & Lee, 2011a). While both studies look at the effects of window form on indoor airflow (Heiselberg et al., 2001), concentrate on drought risk, Gao and Lee (2009) research look at airflow as a passive cooling aspect (Gao & Lee, 2011a). Heiselbeg (2001) tested side-hung and bottom-hung windows in the laboratory (Heiselberg et al., 2001). They concluded that the bottom-hung window is the best option for both single-sided and cross ventilation setups in the winter. On the other hand, bottom-hung curtains would not provide enough ventilation to a single-sided space in the summer. Gao and Lee (2011) used CFD to explore four styles of windows shown in Figure 2.16, side-hung, tophung, full end-slider, and half end-slider. Complete end-slider and side-hung windows were found to work better for cross ventilation, while side-hung windows were the best choice for single-sided ventilation (Gao & Lee, 2011a).

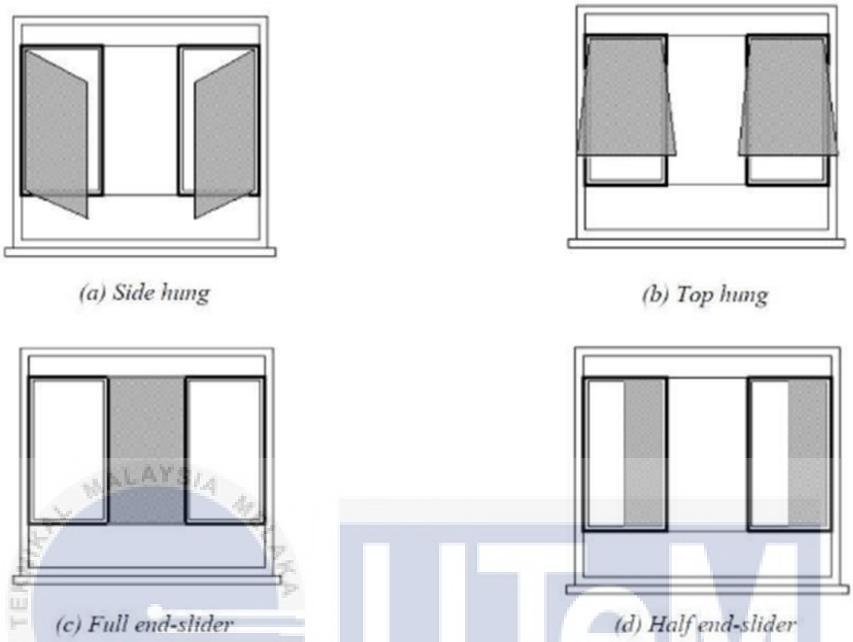


Figure 2.16 Types of windows. Source: (Gao & Lee, 2011b).

Von Grabe (2014) investigated the ventilation efficiency of six different window styles shown in Figure 2.17 for buoyancy-induced ventilation (von Grabe et al., 2014) based on wind-driven ventilation. According to findings, horizontal pivot windows performed the highest in ventilation, while tilt windows performed the worst (Gao & Lee, 2011a; Heiselberg et al., 2001). As part of their research, they tested the efficiency of the above window styles in different wind directions. Their findings revealed that side-hung windows performed better in windward environments, while bottom-hung windows performed better overall (Wang et al., 2015). The effect of slot louvers on single-sided ventilation air change rate has recently been studied (O'Sullivan & Kolokotroni, 2017). When louvers were used instead of a plain opening, an average improvement of 6.5 percent in air change rate was recorded.

Figure 2.17 Six different window shows, (a) double vertical slide window, (b) turn window, (c) bottom-hung window, (d) awning window, (e) horizontal pivot window, and (f) vertical pivot window. Source: (von Grabe et al., 2014)

2.8.4 Balconies and wing walls

Balconies are another feature of a building's exterior that can affect natural ventilation. Balconies are a typical architectural feature in subtropical climates (Buys, Laurie, Summerville, Jennifer, Bell, Lorraine, & Kennedy, 2008). It can be used as a private outdoor space while still theoretically improving indoor airflow.

There have been several research looking at the effect of having balconies. Low-rise structures have poor indoor ventilation. According to Decker and Prianto, balconies substantially impact indoor airflow and increase internal air velocity (Prianto & Depecker, 2002). Chand and colleagues (Chand et al., 1998) Experimented to see how the presence of a balcony affects the distribution of pressure on the building's façade. They discovered that wind pressure balance changes on the windward side but not on the leeward side and that using a balcony raises wind pressure in most situations. While Chand et al. research .'s focused on pressure diffusion on a case model with no openings, their experimental data was later used for CFD validation and evaluation of the impact of balcony provision on indoor ventilation efficiency (Ai et al., 2011), and as well as thermal comfort (Ai et al., 2011). They ran simulations of small and wide openings for single-sided and cross ventilation setups. In single-sided ventilation, simulation findings showed that mass flow rate increases and average velocity decrease, while cross ventilation showed no noticeable improvement (Ai et al., 2011). Thermal comfort status was also stated with no progress using the extended Predicted Mean Vote (PMV) (Ai et al., 2011).

While these experiments looked at the impact of balconies on natural ventilation, they all relied on simplistic geometries and the combined effect of balcony features, for example, balcony width and depth. Other determinant parameters, such as ventilation mode and incident wind speed, have not been thoroughly studied. Another architectural aspect that influences indoor airflow is wing walls.

By generating pressure differentials, natural ventilation can be achieved (Aynsley, 2007). In a wind tunnel, (Givoni & Foundation., 1962; Givoni et al., 1968) explored the influence of wing walls on natural ventilation. Wind speeds and directions were measured in a space with and without wing walls. The findings of the experiments showed that adding wing walls to single-sided ventilation would dramatically increase natural ventilation and indoor air circulation. Experiment CFD was used to examine the influence of wing walls on single-sided ventilation efficiency under various wind directions (Mak et al., 2007). Like Givoni's research, Wing walls were discovered to increase ventilation efficiency by increasing indoor air velocity and air change rate. The application of wing walls at a 45-degree angle was the most effective among the incident wind directions assessed. (Mak et al., 2007).

2.9 Computational fluid dynamics (CFD)

Computational Fluid Dynamics (CFD) is a subfield of fluid mechanics that solves and analyses fluid flow problems using a numerical approach and algorithms. CFD forecasts the fluid problem by describing and solving the fluid flow case mathematics equation. The mathematical technique incorporates the finite deference method, finite element techniques, and the filter-scheme method. Nowadays, airflow analysis can be effectively implemented using the CFD approach under somewhat difficult settings such as non-isothermal, three-dimensional, and with appliances inside the space(Cao et al., 2022).

The commercial and research codes are the two primary kinds of CFD. FLUENT, STAR-CD, and CFX are examples of commercial programmes for computational corporations that are acceptable for general use. FLUENT will be utilised in the simulation process at the evacuation centre for this investigation(Eltayeb et al., 2019).

CFD may be used in a variety of study areas. One of the topics that benefited the most from the creation of the CFD approach was aerodynamics. CFD may be used to collect information about the flow field, such as shear stress, velocity and pressure profiles, and flow streamlines (Alkhabbaz et al., 2022).

2.9.1 Structure of CFD

When working with ANSYS CFD software, there are three main components that must be understood. The pre-processor is the initial component. It is made up of three primary components: geometry, meshing, and animation. The pre-processor function is used to define the problem, create the necessary geometry, and generate and manipulate the mesh. During this step, the parameters of the domain fluid and the materials utilised in the model should be described (You et al., 2021).

The solver is the following component. It is used to carry out the computations and numerical solutions to the problem specified previously. The numerical methods utilised in CFD includehe the finite difference technique, finite volume method, and finite element method (Romanowski et al., 2019; You et al., 2021).

Finally, the post-processor component will present or create the configuration of the simulated flow issue by exhibiting the geometry of the problem, the computational domain, and the mesh system (Eltayeb et al., 2019).

2.9.2 Turbulence modelling

Turbulence is defined as any chaotic explanation for the 3-D Navier-Strokes equations that is sensitive to beginning data and develops as a result of consecutive instabilities of laminar flows when a bifurcation parameter is increased through a series of values (Bejan & Cunnington, 1983).

The preceding sentence is about turbulence in CF. Turbulence is a complicated activity, and the specifics of turbulence motion are to a tiny scale in diameter. Turbulence flow simulations using CFD are more complex than laminar flow simulations. Turbulence flow is always unsteady, and three-dimensional – random, whirling, vertical structure termed turbulence eddies of various orientations develop in turbulence. The features that should be noticed and examined using such numerical simulations are connected to the complexity of various turbulence models (Romanowski et al., 2019).

2.10 Previous researchers

The description of the past researchers on airflow simulation study is listed in a simple style in Table 2.4. The parameters included in the table are the temperature and velocity following the study to be conducted.

Table 2.4 Previous researcher velocity and temperature data

Researchers	Type of Study	Description
(de Dear et al., 1991)	Statistics for 583 sets of interior climate measurements in re-ventilated buildings	Air measurements in buildings using natural air in Singapore revealed that the temperature was 29.5 ° C, the humidity was 74%, and the wind speed was 0.22 m/s.
(Samirah Abdul & Kannan, 1996)	Simulation of airflow and thermal comfort in the classroom	CFD was used to model airflow and thermal comfort in naturally ventilated classrooms with various layouts, combinations, and outside environmental conditions. The velocity measured was 0.77m/s, and the temperature was 29.42°C.
(Lim et al., 2002)	Airflow Simulation in Classrooms	The goal of this work was to simulate airflow in a lecture room using CFD. For measuring and stimulation reasons, a comparison was made between two lecture rooms with varied air-conditioning unit locations. Parameters assume that a variation in air velocity of less than 0.10 m/s is insignificant and minor and that a temperature difference of less than 1°C is insignificant. According to this study, the RNG k-e Turbulence Model forecasts air temperature more precisely than the Reynolds Stress Turbulence Model.

Table 2.4 (Cont.) Previous researcher velocity and temperature data

Researchers	Type of Study	Description
(Nugroho et al., 2007)	Simulation of wind speed of house building using CFD	The study was conducted in a terrace house building to obtain thermal comfort in the house. The study was conducted using CFD in solving the problems faced by the population. The results of the study found that the wind speed in the building is 0.6 m/s, and the temperature is 27.5.

2.11 Summary

In conclusion, this chapter 2 has studied the floods in Malaysia and especially in Melaka. The existence of this study, to some extent, helps in preparing this thesis. Selecting a place to collect data in the following process will be easier with the data from certain parties. As flood risk areas will be easily identified, temporary settlements in the Melaka Tengah area have also been listed. Next is natural ventilation as a passive cooling system provides several benefits, including energy savings, improved indoor air quality, and thermal comfort. Natural ventilation is controlled by various architectural characteristics, including ventilation mode, building height, the design of apertures, balconies and projections, and interior obstructions, in addition to climatic-driven factors like wind. As a result, proper incorporation of these architectural aspects can increase natural ventilation. The opening design has been widely investigated among design-related characteristics. Thermal comfort is an acceptable criterion for assessing natural ventilation effectiveness since one of the significant aims of natural ventilation is to provide a cooling impact for building occupants. And based on previous studies, some input can be used as a guideline, such as the use of CFDs. The appropriate CFD selection for this study is Ansys Workbench. Research methods can also be learned while reviewing previous studies. The parameters used in the CFD simulation are temperature and wind speed. The study can be continued using the selected software with these two parameters. As a result, a comfort model that correctly forecasts the thermal state in naturally ventilated buildings and integrates air velocity as input is required for natural ventilation performance evaluation.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section will look into the approach and techniques used during the research. The method used in a study or project is crucial. The methodology aids the study's procedure to ensure that it may be finished effectively. To fulfil the study's aims, the methodology section has various components. In addition, the methods of measurement are also addressed in this chapter. A flow chart helps us define and clarify the process in this study properly. This allows us to finish the investigations more expediently. Figure 3.1 shows the methodology flow chart.

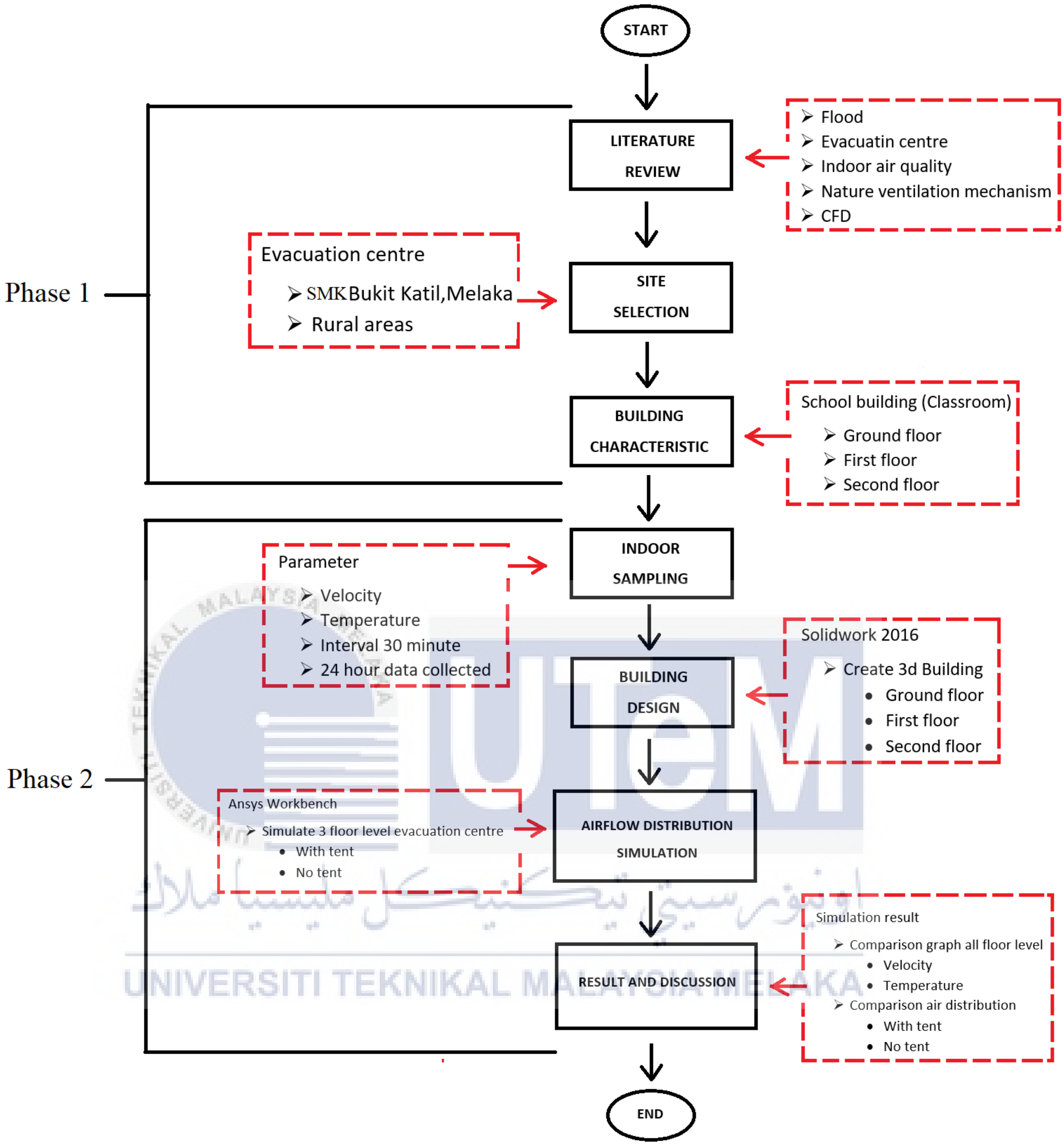


Figure 3.1Methodology flow chart

3.2 Site Selection

In this research the place chosen is a SMK Bukit katil located in Km 9, Jalan Tun Kudu, 75450 Bukit Katil, Melaka. SMK Bukit Katil is because this school is listed as one of the temporary evacuation centres in the Melaka area. To conduct the study in this school, we have obtained support and assistance from the Melaka State Social Welfare Department (JKM). That is support in terms of tent lending assistance from them (Appendix I). We also got approval from the Melaka State Education Department (JPN) to conduct research at their premises (Appendix H). And the school also allowed us to do research in the classroom that was used as a flood evacuation centre at the school. Class parameters were taken in 3 different classrooms, namely, ground floor, first floor, and second floor. These three classes have the same area of 63.75m². All of these classrooms have two entrances and four windows. On the west side of the classroom, there are three windows facing the school field, and on the east side, there are two doors and one window facing the classroom building block. In the south and north, there are no casement windows or doors in all classrooms. Figure 3.2 shows the SMK Bukit Katil front view. Figure 3.3 shows a picture of class 5 Akaun classroom on the ground floor, Figure 3.4 shows a picture of class 3 Arif classroom, which is on the first floor, and Figure 3.5 shows a picture of classroom 2 Arif is on the third floor.

Figure 3.2SMK Bukit Katil

Figure 3.3Classroom 1 (5 Akaun) ground floor

Figure 3.4Classroom 2 (2 Arif) first floor

Figure 3.5Classroom 3 (3 Arif) second floor

3.3 Building characteristic

The classroom layout in Figure 3.6 shows the dimension of the classroom 5 Akaun, 2 Arif and, 3 Arif. All classrooms are the same size. And Table 3.1 shows detailed parameters for all classrooms.

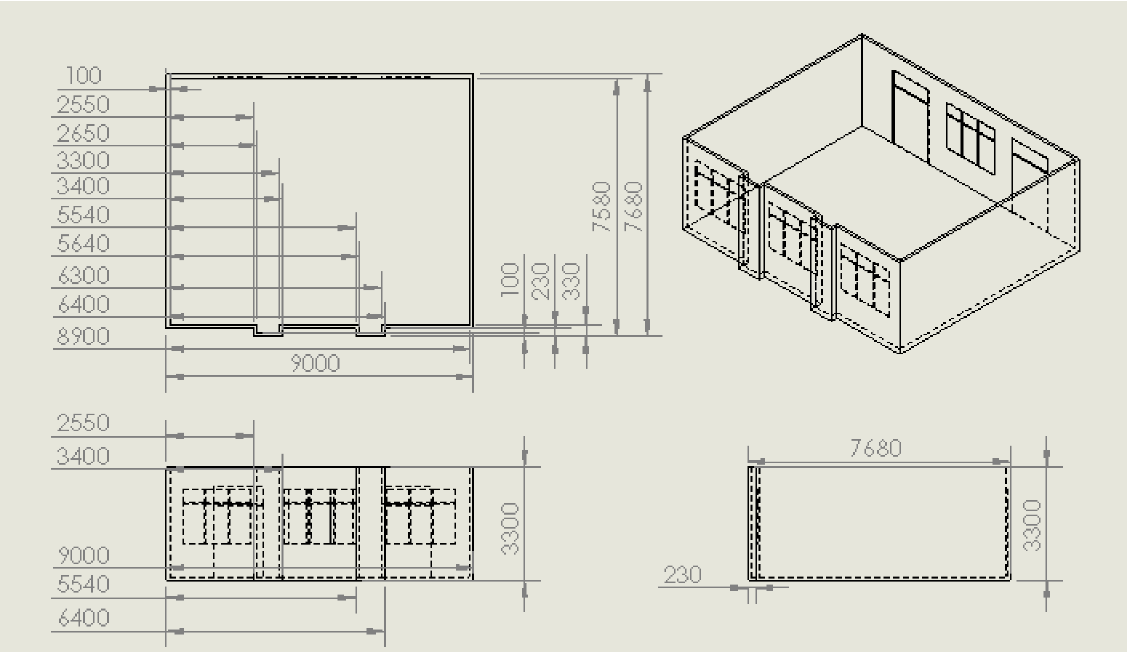


Figure 3.6 Classroom layout (All units in mm)

Table 3.1 Parameter classroom

Building size (LxWxH)	(875cm x 725cm x 320cm) + (66cm x 23cm x 320cm) x 2
Building area	63.75m^2
Classroom and floor level	5 Akaun = Ground floor 2 Arif = First floor 3 Arif = Second floor
Inflow (Exp= W1, W2)	W2, W3,W4
Outflow (Exp= W3, W4)	D1, D2, W1
Ceiling material	Concrete Ceilings
Floor material	Concrete
Wall material	Concrete and plaster
Window type	Jalousie
Position opening	North= None East= D1, D2, W1 Soulth = None West= W2, W3, W3
Tent quantity	2
Tent type	Disaster tent
Tent size	222cm x 226cm x 187cm
Window quantity	4
Door quantity	2
Lamp quantity	12
Ceiling Fan quantity	4

All classrooms have the same space and position of windows and doors. There are four windows and two doors for each classroom. There are 2 Tents installed in the classroom and named Tent 1 and Tent 2. Window 1 (W1), door 1 (D1), and door 2 (D2) are facing East, and door 2, door 3, door four are facing to the west. Figure 3.7 shows the displays and labels on each door, window, and tent.

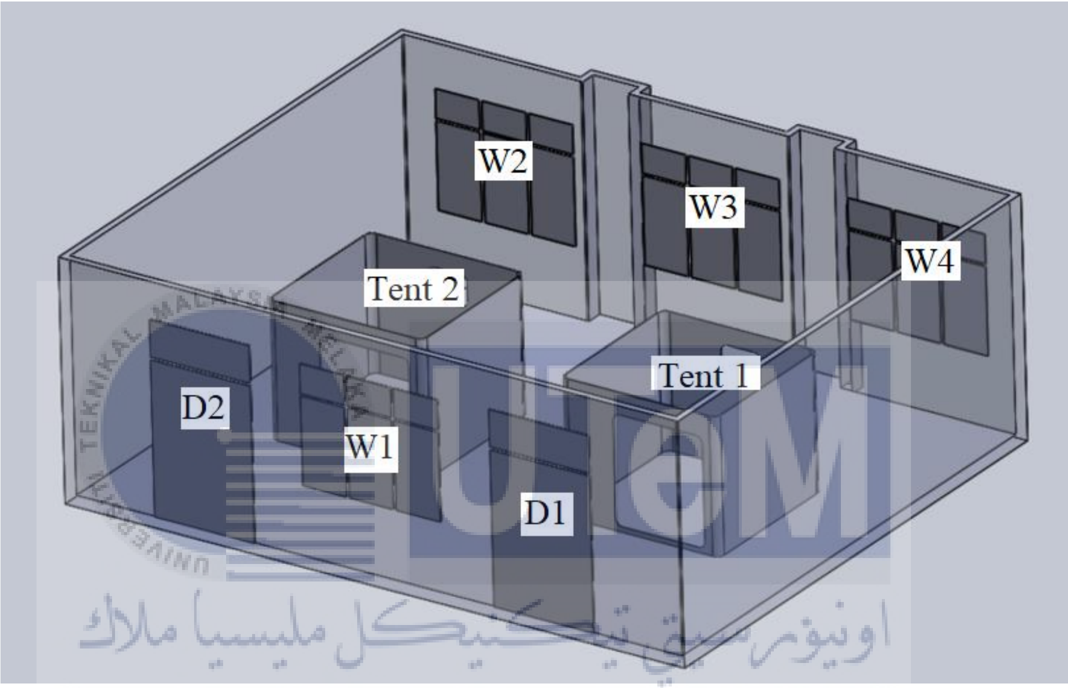


Figure 3.7Door, window, and tent label (all classes)

3.4 Indoor sampling

Indoor air sampling explains the process while taking data in the evacuation centre. All sampling has the research parameters mentioned in the Department of Occupational Safety And Health (DOSH, 2010). Here also explains the parameters, sampling sport, experiment setup, equipment, and data acquisition.

3.4.1 Product parameters' Measurement & Analysis

The sampling strategies are categorized by the number of sampling spots, where they are located, the length of the sampling period, and sampling methodologies according to the standards from the industry code of practice on indoor air quality 2010 of Industry Department Of Occupational Safety And Health Ministry Of Human Resources, Malaysia (DOSH, 2010). This measurement should take around twenty-four hours (24 hours) to complete. However, data are being gathered every thirteen minutes (30 minutes). This is the data that has been obtained by the equipment and research instruments given by the institution and supervisor.

3.4.2 The number of sampling spots

The usual number of sample points is necessary. One of the experiment location is in the classroom, with dimensions of (875cm x 725cm x 320cm) + (66cm x 23cm x 320cm) x 2, resulting in a surface area of 63.75m^2. The recommendation is a minimum number of sampling points for IAQ is listed in Table 3.2.

Table 3.2 Recommendation in a minimum number of sampling points for IAQ Assessment DOSH (DOSH, 2010)

Total floor area (by MVAC system) m^2	Minimum number of sampling points
Less than 3,000	1 per 500m^2
3,000 - < 5,000	8
5,000 - < 10,000	12
10,000 - < 15,000	15
15,000 - < 20,000	18
20,000 - < 30,000	21
More than and equal 30,000	1 per 1,200m^2

3.4.3 Experimental Setup

The venue for the live measurements was arranged to be a classroom at one of Melaka's schools. The data were examined for 24 hours during an experiment. The information gathered will be used to assess the ventilation velocity of the wind about the internal airflow. As a result, the duration of the tests was deemed adequate for these reasons. Only airflow in the classroom area was measured in most experiments. Anemometers will be installed in several places to identify air inlets and air outlets in the area. And during data retrieval, no fan assistance devices or mechanical ventilation were used. The location of the sensors in the case study for all test preparations is shown in Figure 3.8.

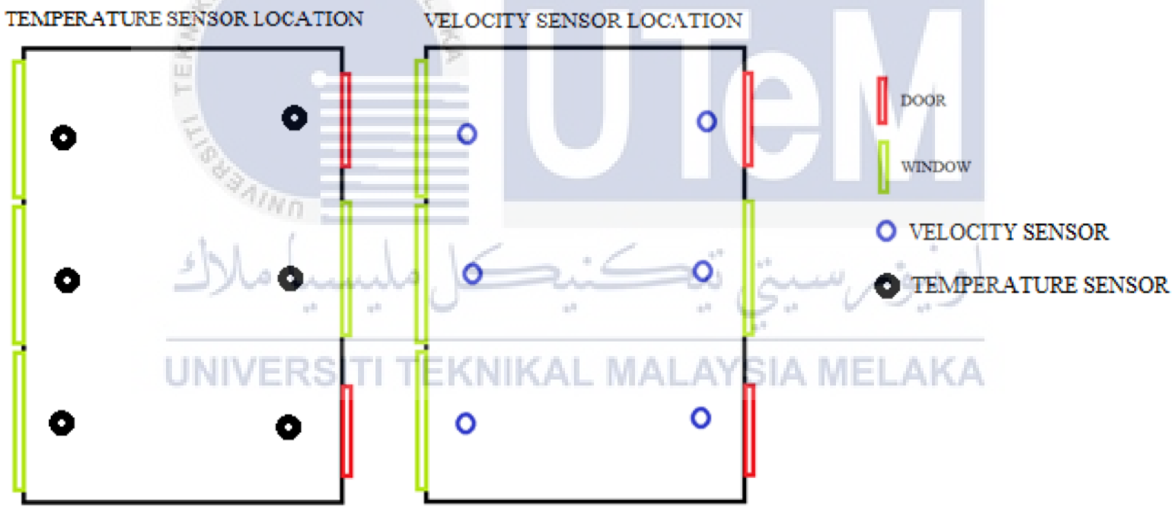


Figure 3.8Sensor placement in the classroom for various test setups.

3.4.4 Equipment

Data collection and experimental equipment two types of anemometers were used to monitor air velocity at various locations. One is a velocicalc, and another one is an anemometer, capable of measuring airspeed and direction with great precision. All of the equipment was set at the height of 1.2 meters, corresponding to the height of a seated adult human's head. All this data will be taken and recorded manually using a datasheet every 30 minutes before being entered into the graft and Ansys CFD software. The measuring tape is used to measure the area in the classroom and tent size. The specifications for the instruments are listed in Table 3.3.

Table 3.3 Instruments' specifications

No	Instrument	Accuracy and resolution	Images
1	Tube anemometer velocicalc (Temperature & velocity)	Velocity Speed: 0.1~25.0m/s Accuracy: ±(5%+1d) reading	
2	Vane anemometer (Temperature & velocity)	Velocity Speed: 0.00 - 30.00 m/s Resolution: 0.01 m/s Threshold: 0.3 Accuracy: ±(5% + 0.1 m/s) Temperature °C= -10°C - +45°C Resolution: 0.1 Accuracy: ±2°C	
3	Measuring tape	Length: 5 meters Accuracy: ±1mm	

3.4.5 Equipment installation and measurement process

Table 3.4 shows the process of classroom parameter measurement and installation equipment. Several parameters are to be measured, including building area, tent size, window size, door size, temperature, and airflow. And for installation, a tent inside the classroom should be before the equipment measurement is installed. The process of all three classroom measurements and installation of this equipment begins at 7:00 am and finishes at 7:45 am. This preparation took 45 minutes to complete the installation for each classroom.

Table 3.4 Process measurement and preparation equipment

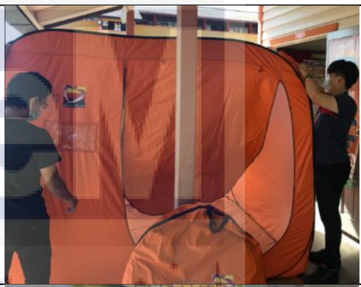
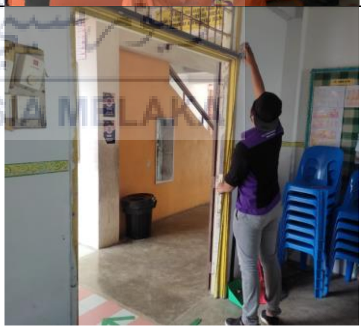
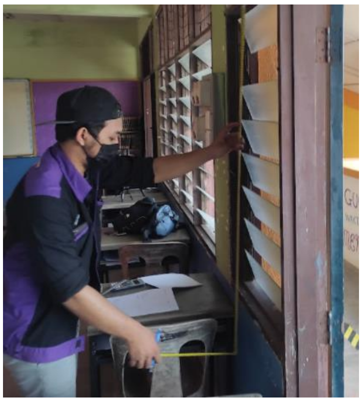
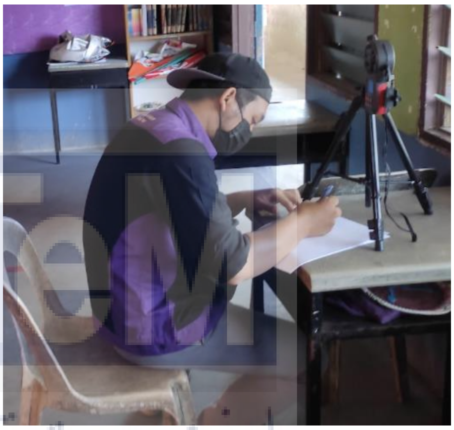
No	Process	Picture
1	Disaster tent installation.	
2	Measurement area in the classroom i) Measure door size ii) Measure window size iii) Measure area classroom	 

Table 3.4 (Cont.) Process measurement and preparation equipment

No	Process	Picture
3	Process measurement tent i) Measure door opening the tent. ii) Measure window tent opening. iii) Measure high, width, length tent.	
4	Installation of anemometer at the designated point. i) Window ii) Door iii) Inside the tent	 

Table 3.4 (Cont.) Process measurement and preparation equipment

No	Process	Picture
5	The manual data retrieval process i) Velocity ii) Temperature iii) Building layout iv) All equipment inside the flood evacuation centre	 
6	Equipment storage after data collection in the evacuation is completed.	

3.4.6 Datasheet

Because the data collection is done manually, the best manual technique to capture the data is being developed. We are making an Airflow datasheet table that includes information such as time, data collection site, velocity, building size, and tent size. Microsoft Word will be the program that will be utilized. The table datasheet is used for data collection and by using OriginPro software to create a graph.

3.5 Building design

Before simulating all classes selected into Ansys workbench CFD, the first thing that must be done is to create a design similar to the study site using SolidWorks by following the parameter in Figure 3.6. Figure 3.9 shows the classroom layout. SolidWorks software is chosen because it is simple to use and straightforward to set up, and it is also affordable. SolidWorks is a computer-aided design (CAD) and computer-aided engineering (CAE) computer application developed by Dassault Systèmes that is primarily designed to operate on Microsoft Windows platforms (SolidWorks, 2015).

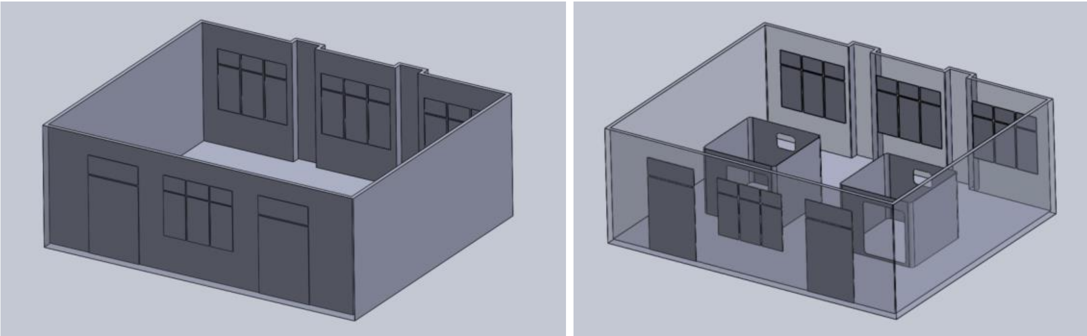


Figure 3.9Classroom layout

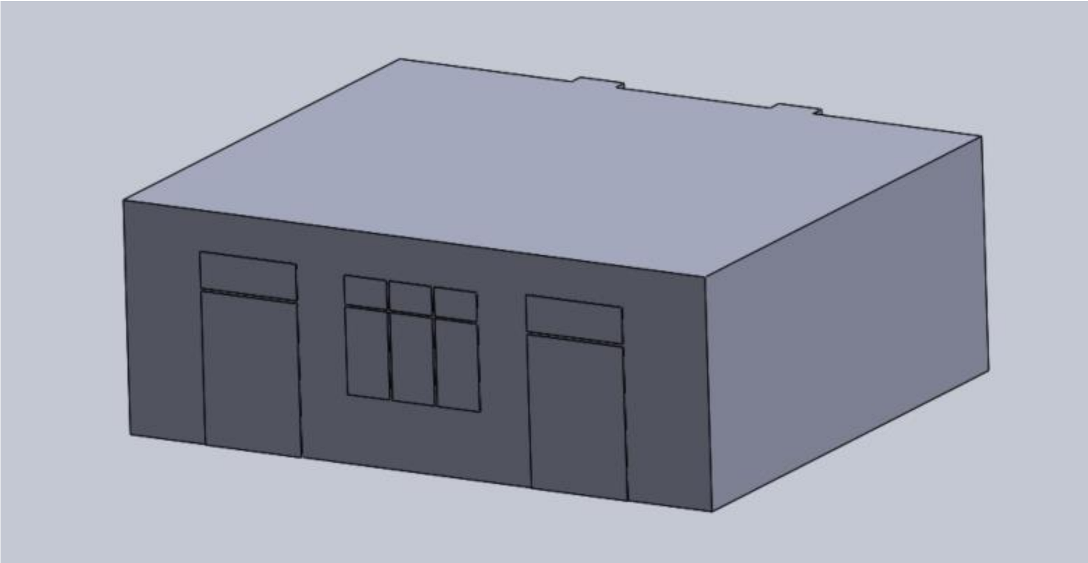


Figure 3.10 Classroom airflow area

3.6 Airflow distribution simulation

Simulating the operation of a real-world process or system over time is called Simulation. The Simulation reflects the evolution of the model through time, whereas the model depicts the main traits or behaviours of the specified system or process. Computers are frequently used to run simulations.

3.6.1 Ansys workbench Computational Fluid Dynamics (CFD)

To achieve the objective, each evacuation centre should be simulated to know the airflow distribution. There are several software that is suitable for use in this study. Among them is the Ansys Workbench software. The Ansys Workbench platform allows you to combine data from several engineering simulations to produce more accurate models faster. By centralizing all of your simulation data in one location, Ansys Workbench makes it easy to make better design decisions. Manage data in all of your Ansys products with ease.

Using this Ansys Workbench, there are two conditions to simulate. The first is a class situation without a tent, and the second is a simulation of a class situation with a tent. Both of these situations will be done for the three classes at different levels, namely class 5 Akaun on the ground floor, class 2 Arif on the first floor and class 3 Arif on the second floor. This simulation will be displayed in streamline view and counter view. The streamline view shows the flow and travel of wind through the inlet, and the counter view is to see more clearly the wind speed in some areas. The parameter in the simulation is set in Table 3.5.

Table 3.5 Parameter set in Ansys Workbench

Classroom	Inlet airflow (m/s)	Temperature (° C)
Ground floor	0.47	27.7
First floor	0.64	27.1
Second floor	1.33	27.2

3.7 Summary

Finally, chapter 3 discusses the methodology used in this research. Start with a flow chart drawing describing the research technique and its conclusions. A case study technique was determined as a viable technique for this thesis based on the objectives and prerequisites of the study. Experimental measurements were conducted on a set of case studies in specific situations. The use of the obtained data and CFDs of the Ansys work table helps address the problem of natural airflow more smoothly. With this methodology, the data taken at the evacuation centre will be more organized.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

For this chapter, the data taken at the evacuation centre will be displayed in graphs and simulations from Ansys Workbench software. The simulation will be made of two conditions. The first is the condition where the class is empty, and the second is the class have the tent has been set up. In addition, all descriptions of trends and ventilation will be described and discussed.

4.2 Indoor data

The data at the evacuation centre, namely SMK Bukit Katil, was able to be graphed into two graphs, namely the velocity graph unit m/s and temperature unit ° C. Data taken at the evacuation centre are shown in Appendix C for class 5 Akaun data on the ground floor, Appendix D for class 2 Arif on the first floor, and Appendix E for class 3 Arif on the second floor.

4.2.1 Velocity

Figure 4.1 shows the ground floor line (blue) average velocity graph shows the wind speed in the classroom on the ground floor. The strongest occurs in the afternoon, where the highest wind speed is 1.04m/s. Wind speeds increase after entering the afternoon zone and slow down in the evening zone. The average wind in the evening is between 0.25 m/s to 0.5 m/s. And in the morning zone, the wind speed is between 0.25 m/s to 0.55 m/s.

With this graph, the wind hovering in the classroom used as the flood evacuation centre is between 0.25m/s to 1.04m/s in 24 hours.

The First floor line (red) shows the average graph velocity vs times on the first floor. The wind speed in the class that is on the first floor, the strongest, occurs in the afternoon, where the highest wind speed is 1.27m/s. Wind speeds increase after entering the afternoon zone and begin to slow down in the evening zone. The average wind in the evening ranges from 0.39 m/s to 0.64 m/s. And in the morning zone, wind speeds vary from 0.25m/s to 0.78 m/s. With this graph, the wind that passes through the classroom that is used as the flood evacuation centre is between 0.25m/s to 1.27 m/s in 24 hours.

The second floor line (black) shows the wind speed in the class that is on the second floor. The strongest occurs in the afternoon, where the highest wind speed is 3.28 m/s. Wind speeds began to increase in the 90th minute, at 9:30 p.m. Wind speeds in the morning range from 0.53 m/s to 3.28 m/s. At the same time, the wind began to subside after entering the afternoon zone, which is between 1.75 m/s to 2.32 m/s. Subsequently, in the evening, wind speeds from 2.3 m/s plummeted down to 0.6 m/s for the zone. Wind speeds passing through this class range from 0.53 m/s to 3.28 m/s.

Shows a combination of 3 different floor velocity classes. The black line shows the class 5 Akaun which is on the ground floor, and then the red line is the velocity line of class 2 Arif which is on the first floor and, the last line is the blue line which is the class 3 Arif line which is on the second floor. In general, the velocity of the class on the second floor is the strongest compared to the first floor and ground floor. Significant differences were more pronounced in the morning zone, which showed the second-floor line soaring up to 3.28 m/s, followed by the first flow velocity of only 0.81 m/s and 0.50 m/s for the ground floor. The afternoon zone also shows the second floor is still high compared to the first and ground floor, which is 2.29 m/s. The second-floor trend is declining and approaching the wind speed of the first floor and ground floor in the evening zone. And after the end of the evening zone, the second-floor wind speed trend decreased and approached the first floor and second floor trend, and the difference is only between 0.2m/s to 0.5m/s between all these trends.

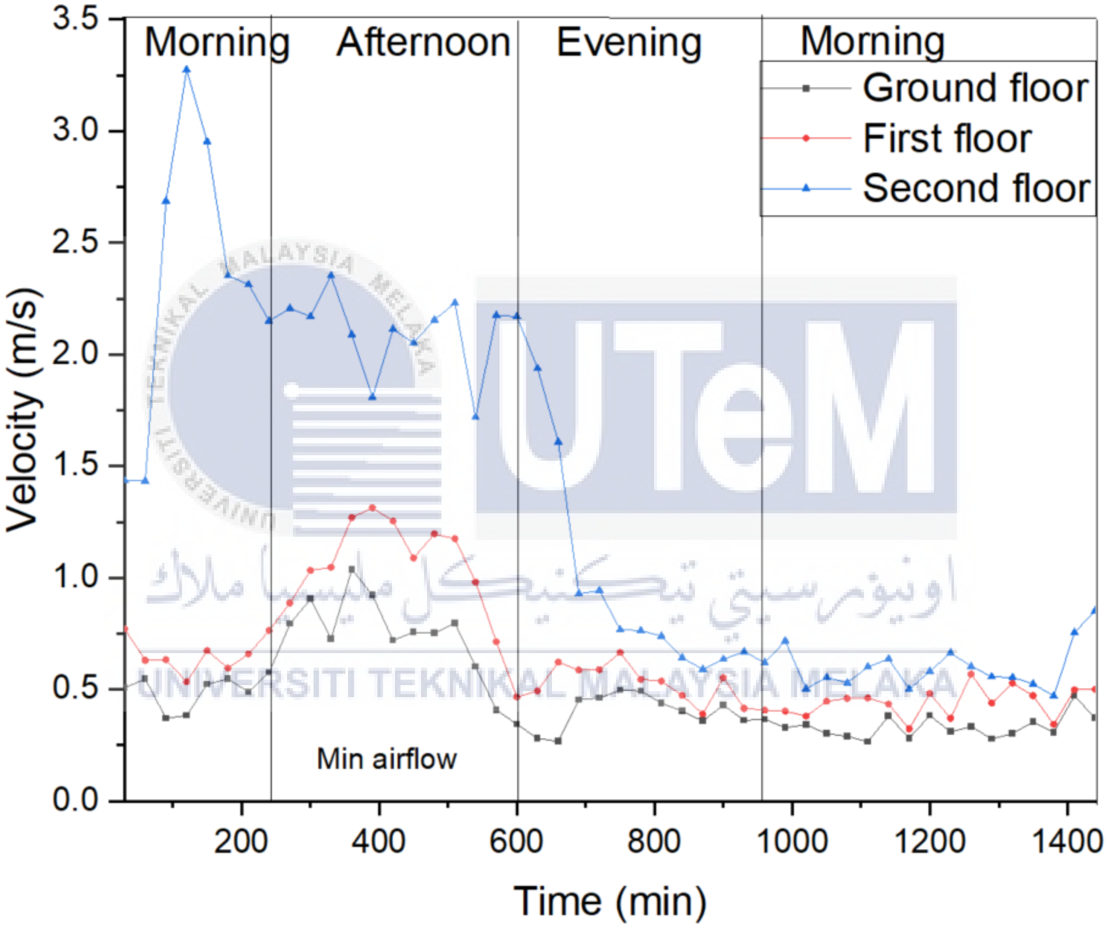


Figure 4.1Graph velocity vs times all floor

4.2.2 Temperature

Figure 4.2 shows the ground floor line (black) shows the temperature taken in class 5 Akaun on the ground floor. Data taken at 8:00 am showed a temperature of 27.6 °C and showed an up and downtrend in the morning zone. The average temperature in the morning zone is between 24 ° C to 28.8 °C. The temperature increased after entering the afternoon zone, which showed that 31.2 ° C was the highest and decreased before entering the evening zone. The evening zone average starts between 29 ° C and drops until 26.3 °C before entering the morning zone. Zone morning, which begins from 00:01 am to 11:59 am, leads to the lowest temperature is 24 °C to 28.8 °C.

The First floor line (red) shows the temperature taken in class 2 Arif on the first floor. Data taken at 8:00 am showed a temperature of 27.4 ° C and showed an up and downtrend in the morning zone. The average temperature in the morning zone is between 24 ° C to 28.4 ° C. The temperature increased after entering the afternoon zone, which showed that 31.2 ° C was the highest and decreased before entering the evening zone. The evening zone average starts between 28.8 ° C and continues to fall until 26.2 ° C before entering the morning zone. Zone morning starts from 00:01 am to 11:59 am with the lowest temperature is 24 ° C to 28.4 ° C.

The second floor line (blue) shows the temperature taken in class 3 Arif on the ground floor. Data taken at 8:00 am showed a temperature of 27.5 ° C and showed an up and downtrend in the morning zone. The average temperature in the morning zone is between 24 ° C to 28.5 ° C. The temperature increased after entering the afternoon zone, which showed that 31.2 ° C was the highest and decreased before entering the evening zone. The evening zone average starts between 28.8 ° C and drops until 26 ° C before entering the morning zone. Zone morning, which begins from 00:01 am to 11:59 am, leads to the lowest temperature is 24 ° C to 28.5 ° C, the highest.

This graph combines three temperature data. Namely, the blue line is the second floor, the red line is the first floor, and the red line is the ground floor. This graph shows that the temperature trend increased at 08:00 am until the hottest peak was in the afternoon zone. After reaching a peak in the afternoon zone with a temperature of 31.2 ° C, the temperature trend declined through the evening zone. Finally, it continued to decrease until entering the morning zone. The three trends do not differ based on observations, but the blue line trend or second floor is hotter than the ground floor and first floor. The difference between the temperatures of the three floors is between 0.1 ° C to 0.5 ° C.

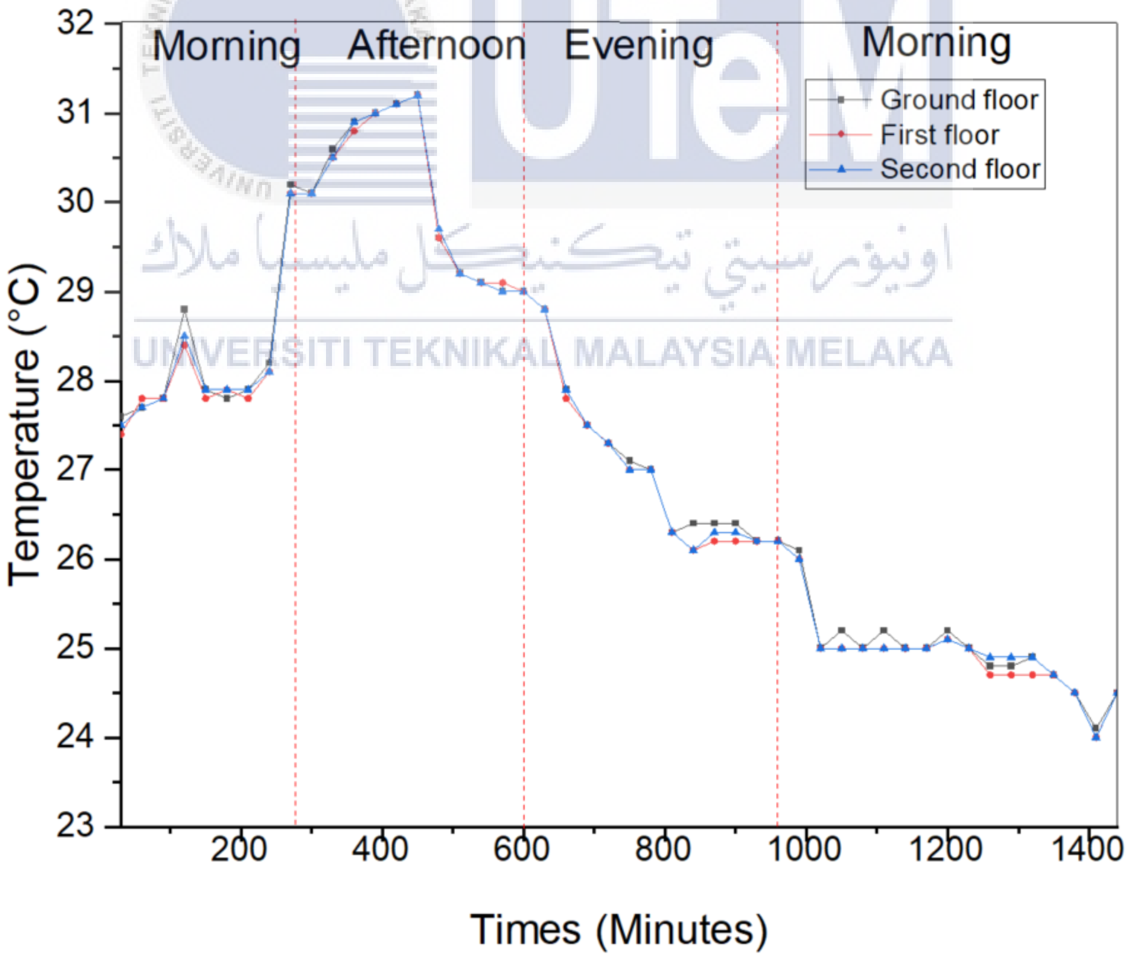


Figure 4.2Graph temperature vs times all floor

4.3 Simulation airflow in an evacuation centre

In this section, the simulation of the actual building and the nature of the airflow from the data taken at all floors will be simulated in the Ansys CFD software. The simulation development is divided into two conditions, the first in the classroom condition with no tents, and the second in the classroom condition paired with two tents. All types of windows are jalousie. The wind speed set into the CFD is 0.47m/s for the ground floor, 0.64 m/s for the first floor and, 1.33m/s for the second floor. This velocity value is based on the average of airflow in the classroom.

4.3.1 Ground floor

Figure 4.3 and Figure 4.4 show streamline view, and Figure 4.5 and Figure 4.6 show contour view of wind velocity of a class that is not fitted with a tent. Descriptions of directional wind flow starting from windows 2, window 3, window 4 flowing to door 1, door 2, and window 1 with wind speeds flowing between 0.00m/s to 0.560 m/s. And the centre of the building wind speed is between 0.112 m/s to 0.448 m/s, and the average wind speed at the centre of the building is 0.28 m/s.

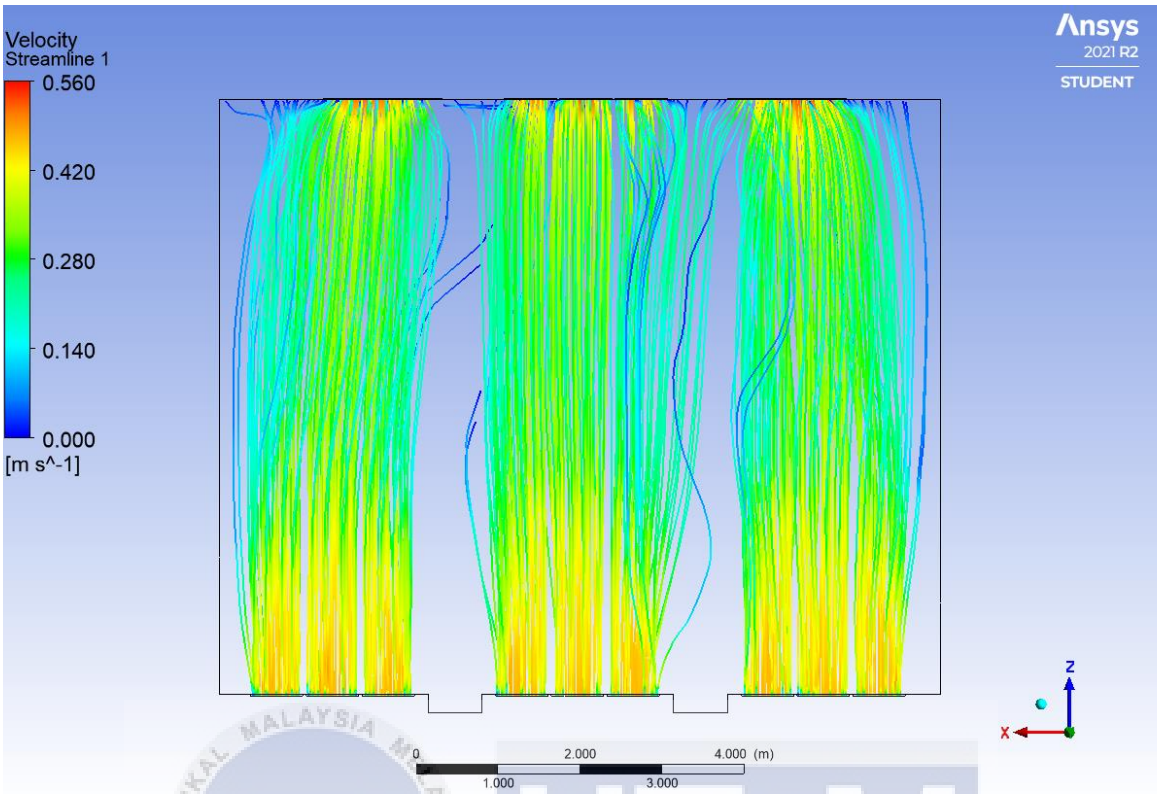


Figure 4.3Streamline view 1 ground floor (no tent)

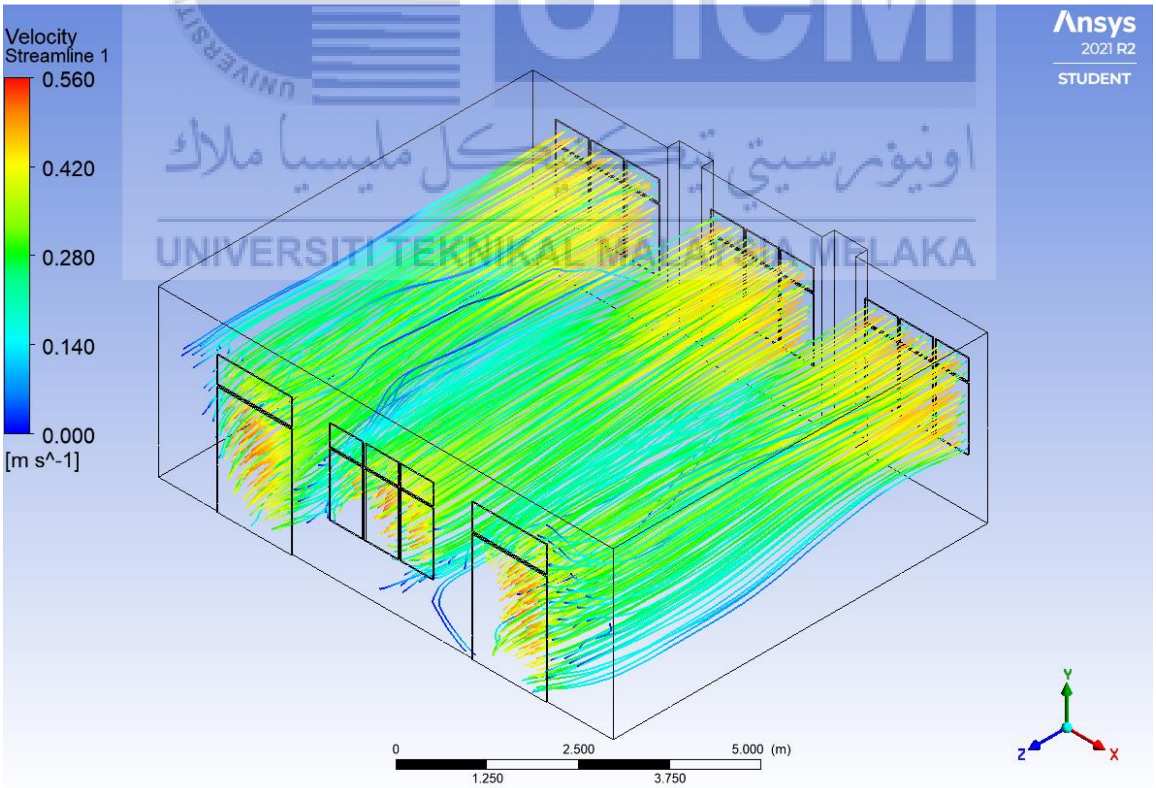


Figure 4.4Streamline view 2 ground floor (no tent)

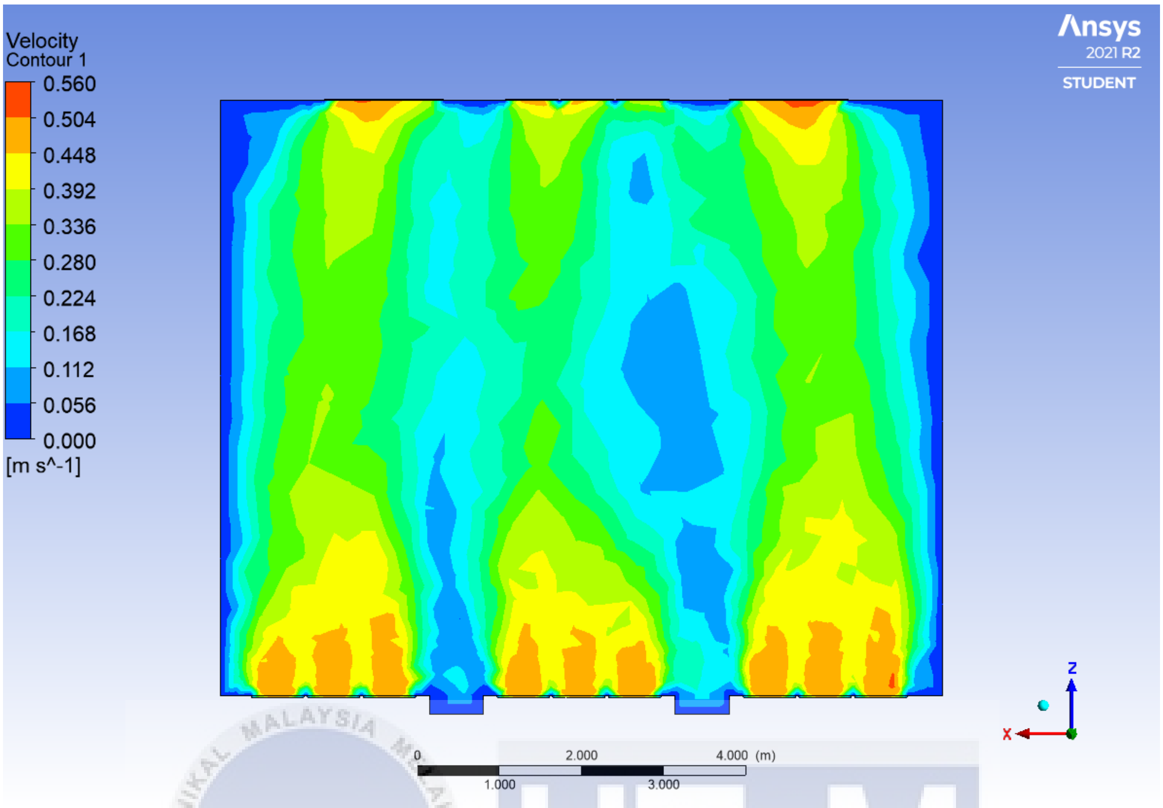


Figure 4.5Contour view 1 ground floor (no tent)

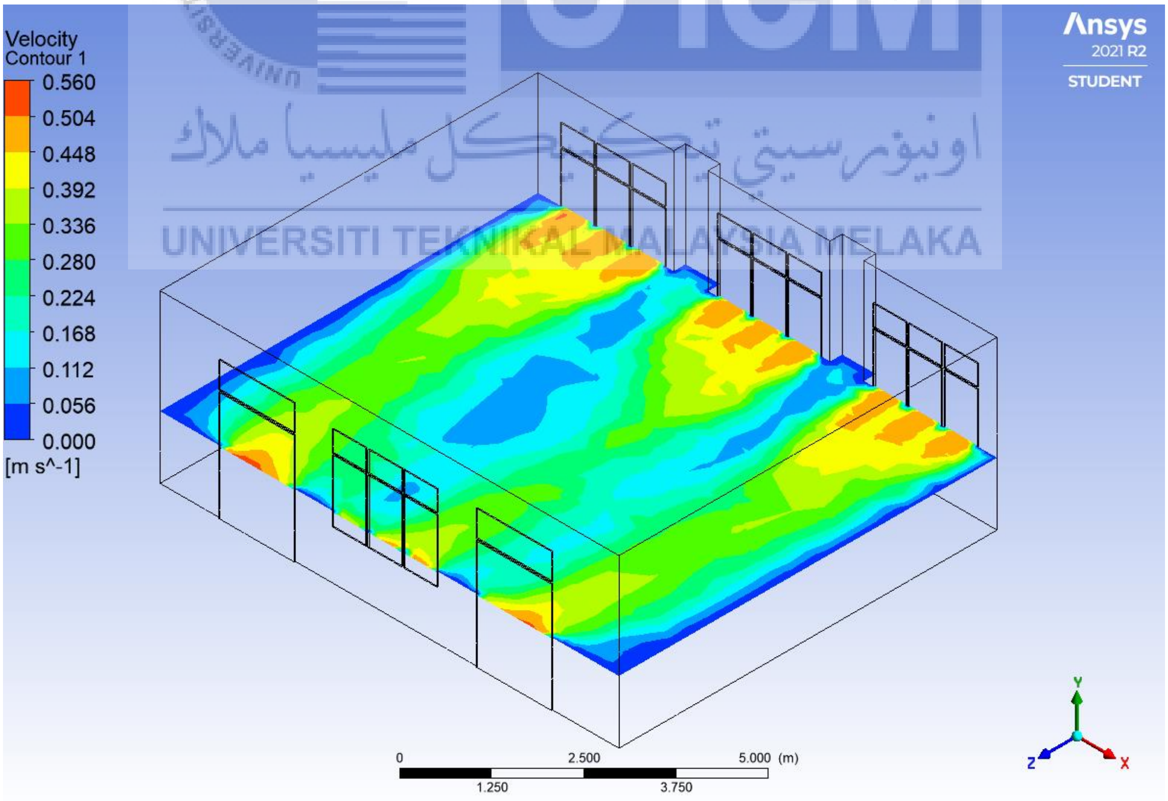


Figure 4.6Contour view 2 ground floor (no tent)

Figure 4.7 and Figure 4.8 show a streamline view, and Figure 4.9 and Figure 4.10 show a contour view of the wind velocity of the class to which the tent has been installed. The incoming wind flow starts from windows 2, 3, 4 and through tent 1 and tent 2 before exiting through door 1, door 2, and window 1 with wind speeds between 0.00 m/s to 0.560 m/s. And the wind speed inside the tent showed readings between 0.00 m/s to 0.289 m/s, and the average is 0.14 m/s.

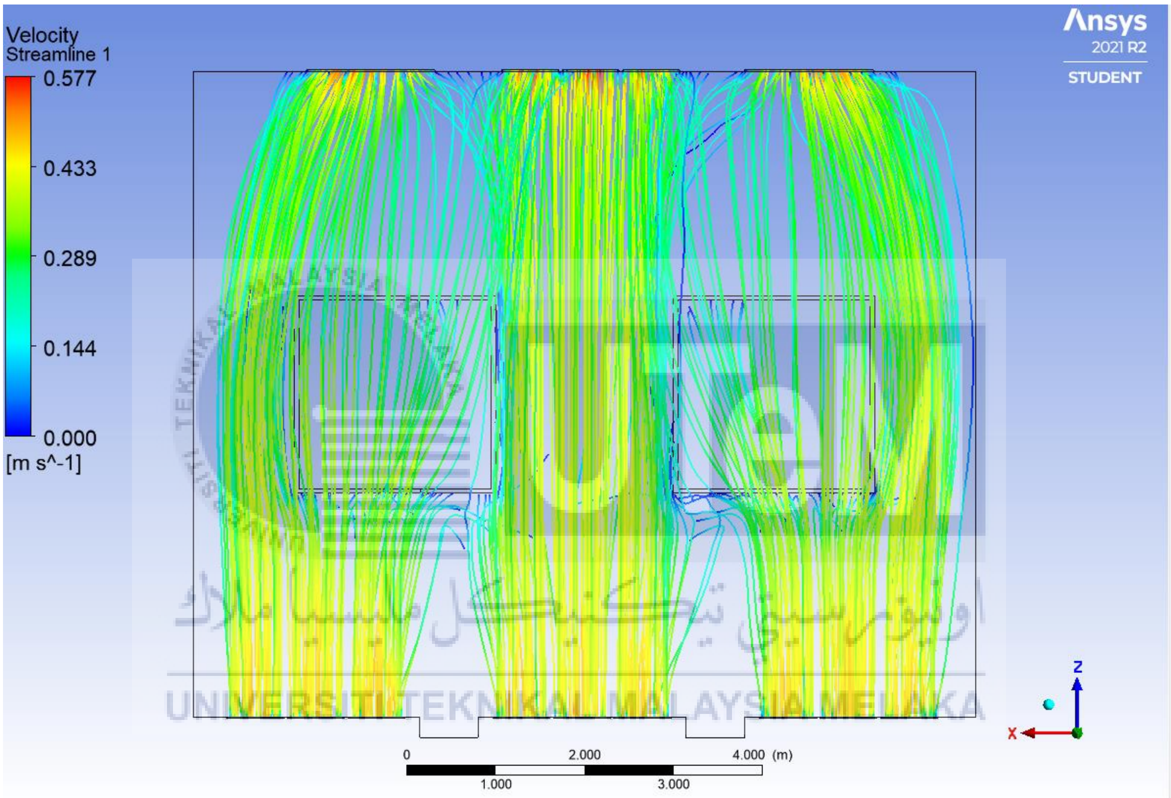


Figure 4.7Streamline view 1 ground floor (included tent)

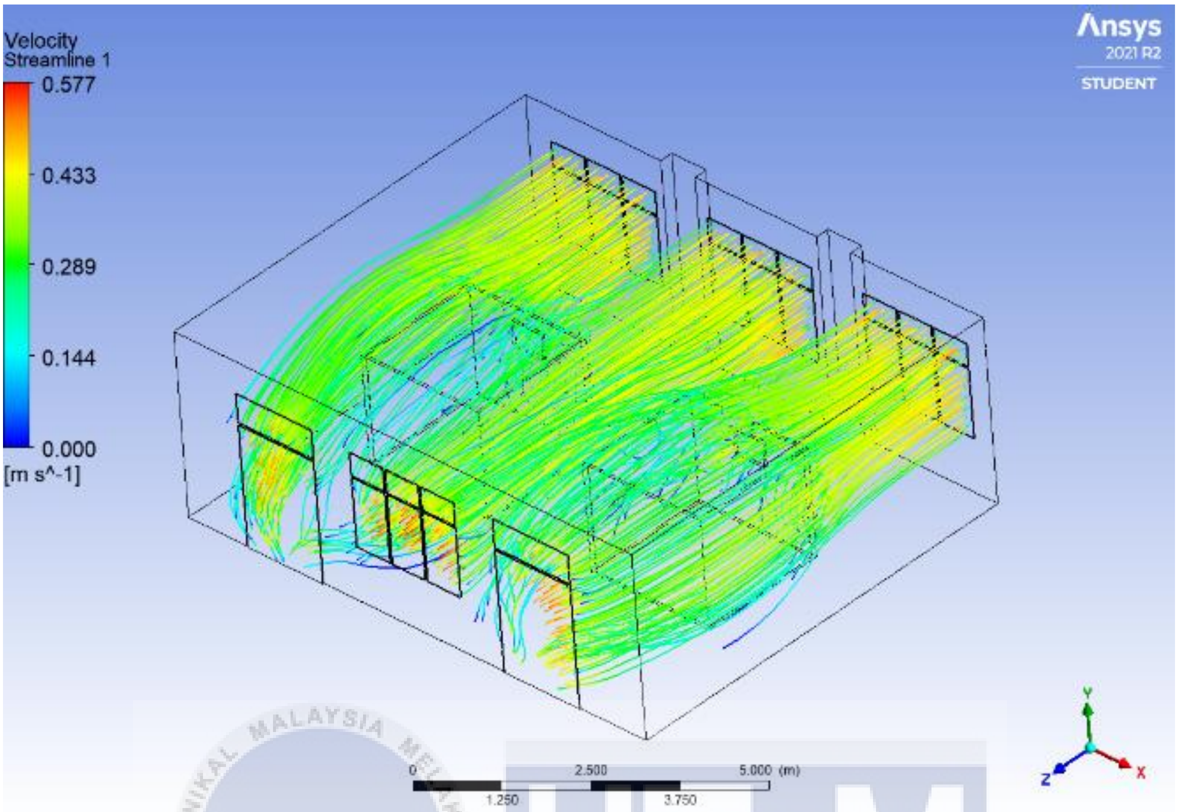


Figure 4.8Streamline view 2 ground floor (included tent)

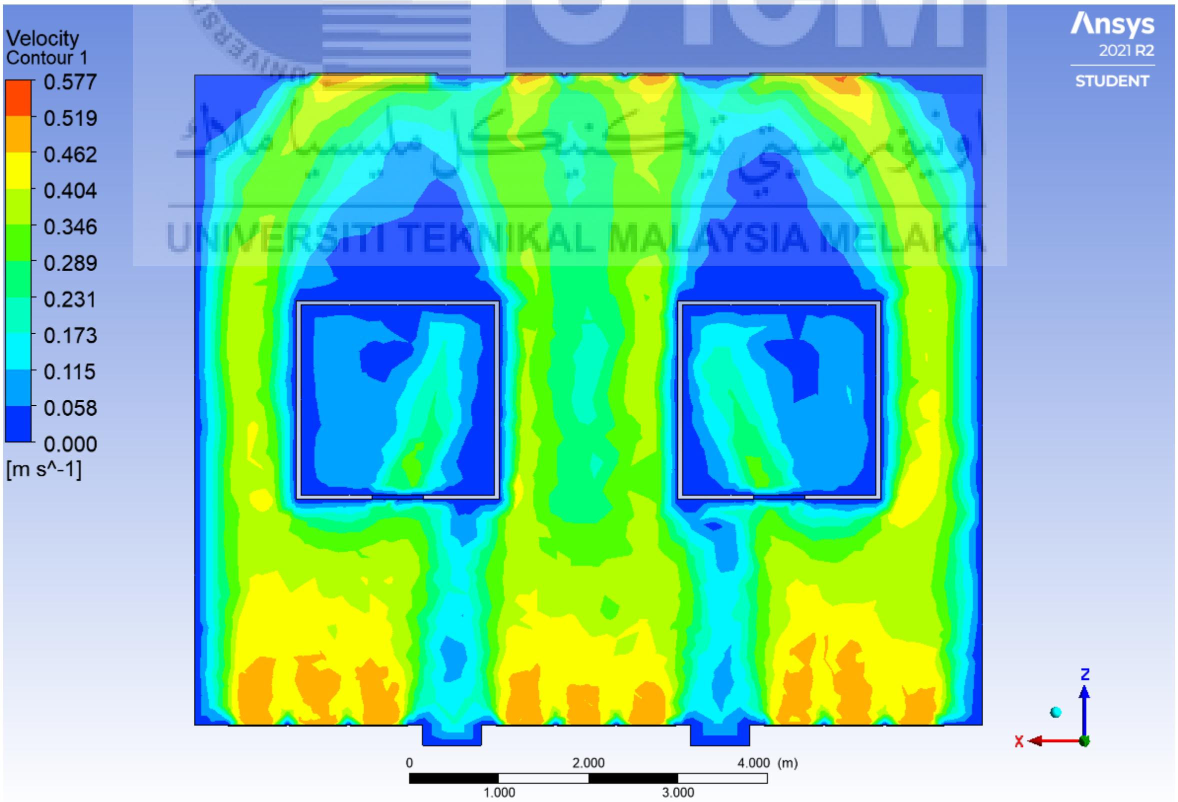


Figure 4.9Contour view 1 ground floor (included tent)

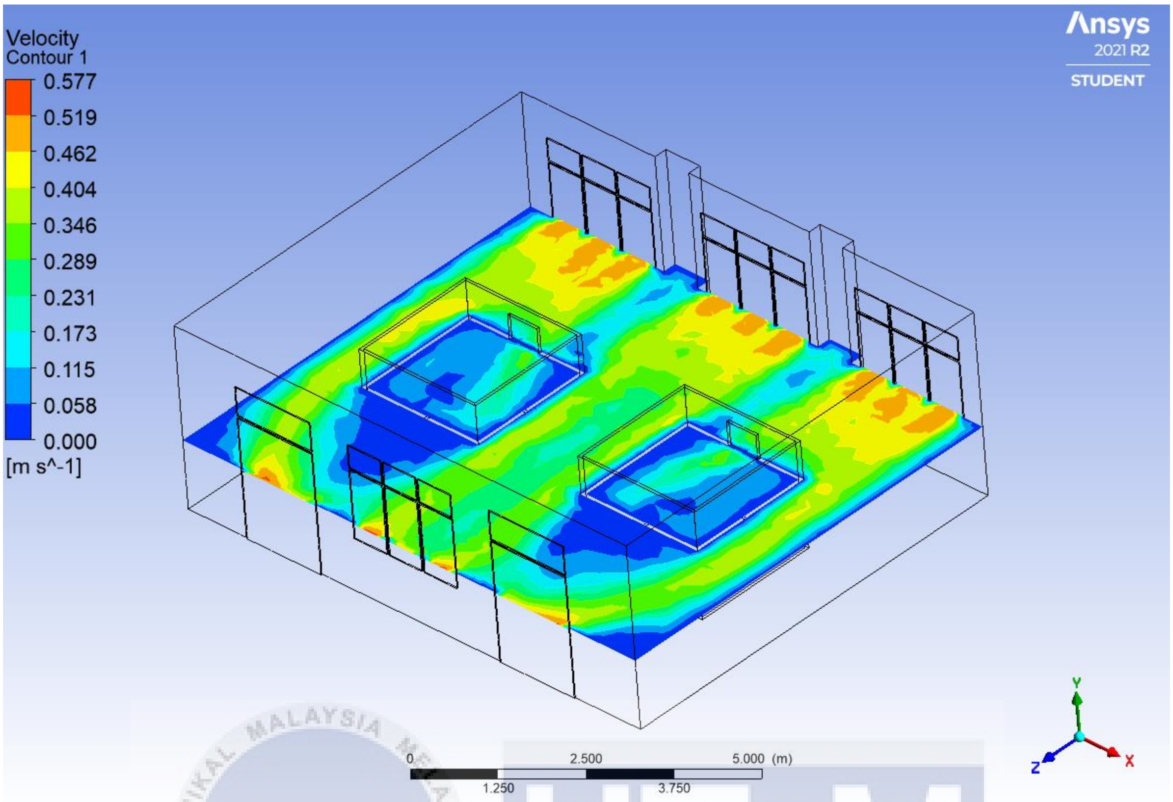


Figure 4.10 Contour view 2 ground floor (included tent)

4.3.2 First floor

Figure 4.11 and Figure 4.12 show a streamline view, and Figure 4.13 and Figure 4.14 show a contour view of the wind velocity of a class that is not tented. The wind flow starts from windows 2, 3, 4 and continues to door 1, door 2, and window 1 with speeds ranging from 0.00 m/s to 0.761 m/s. And the centre of the building wind speed is between 0.152 m/s to 0.533 m/s, and the average wind speed at the centre of the building is 0.34 m/s.

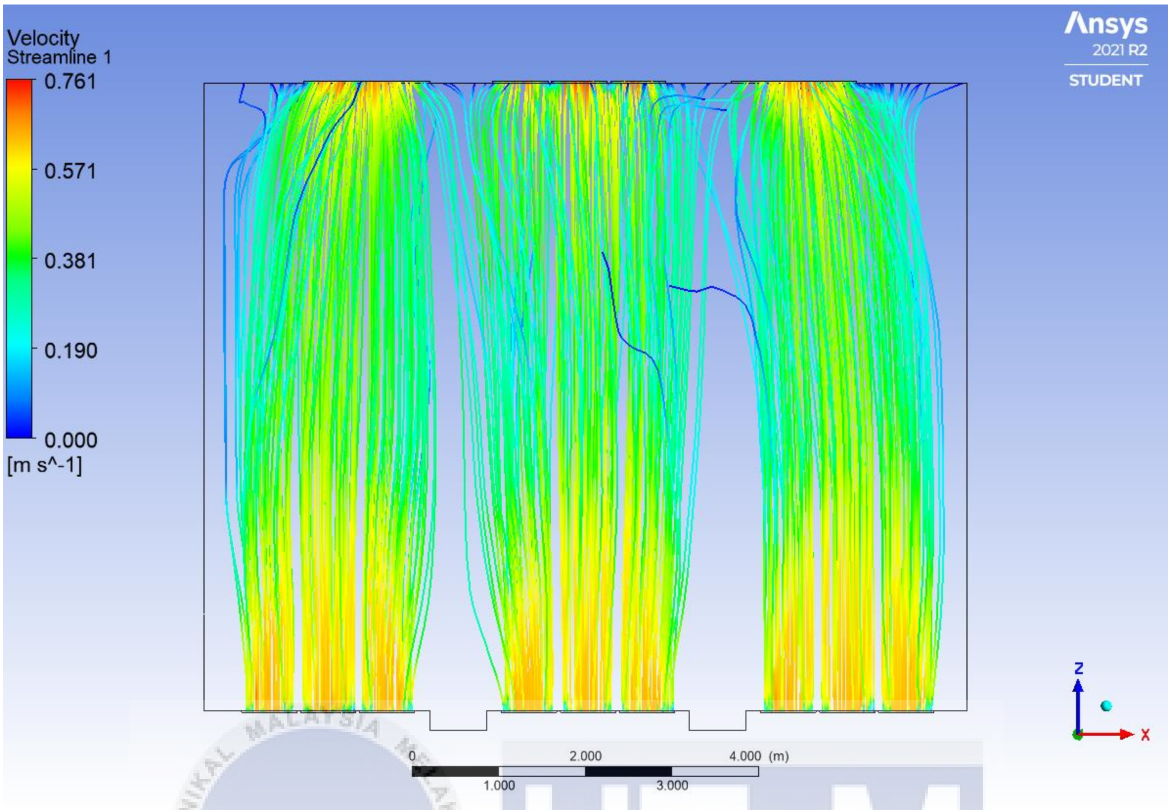


Figure 4.11 Streamline view 1 first floor (no tent)

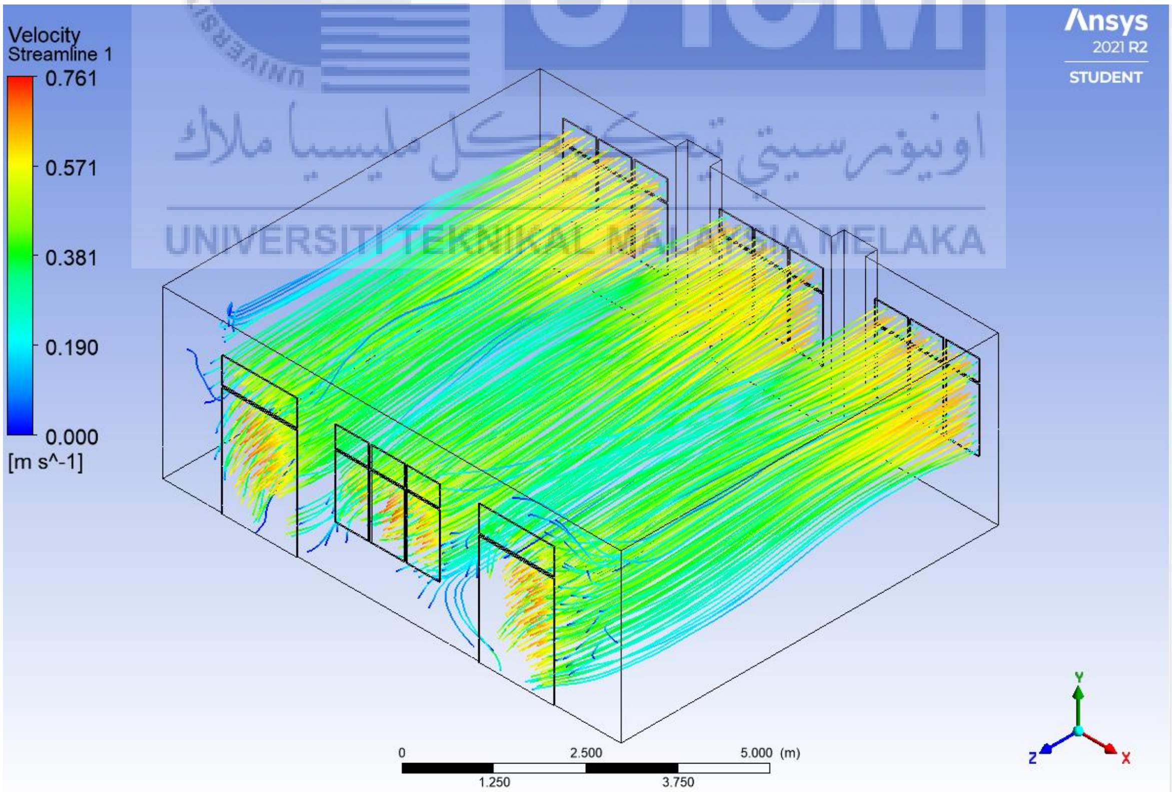


Figure 4.12 Streamline view 2 first floor (no tent)

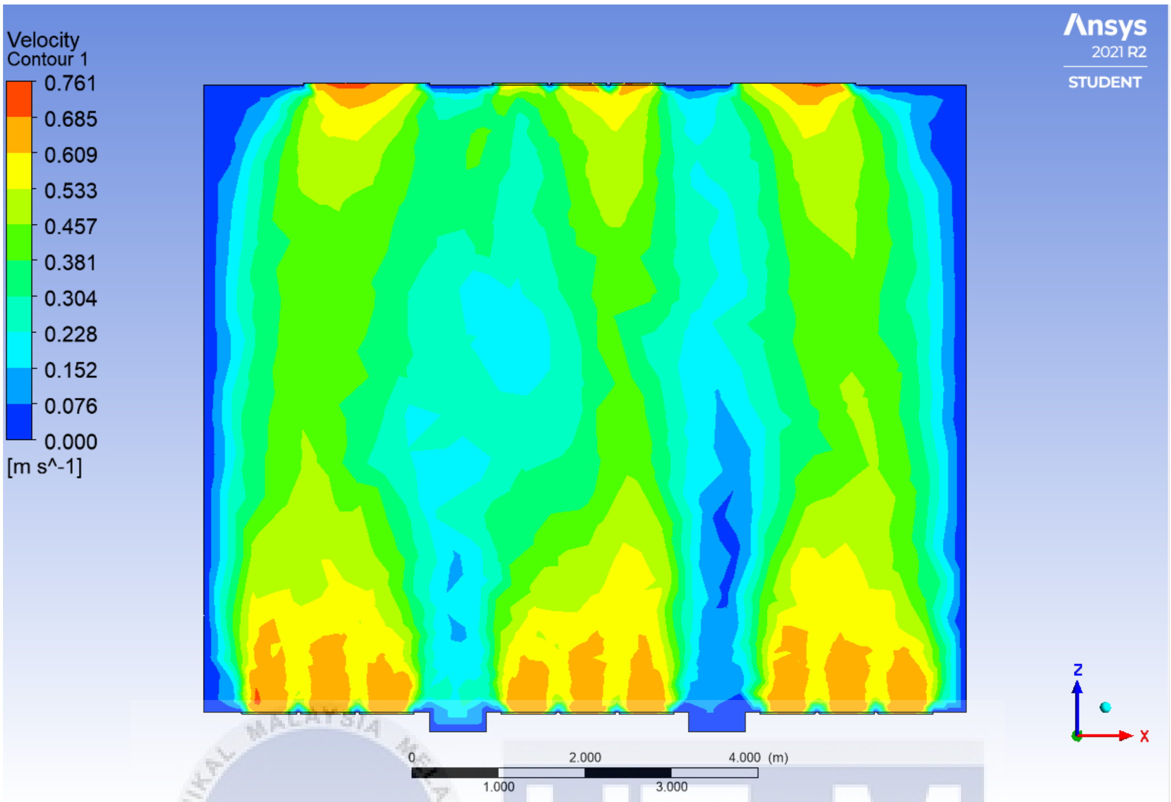


Figure 4.13 Contour view 1 first floor (no tent)

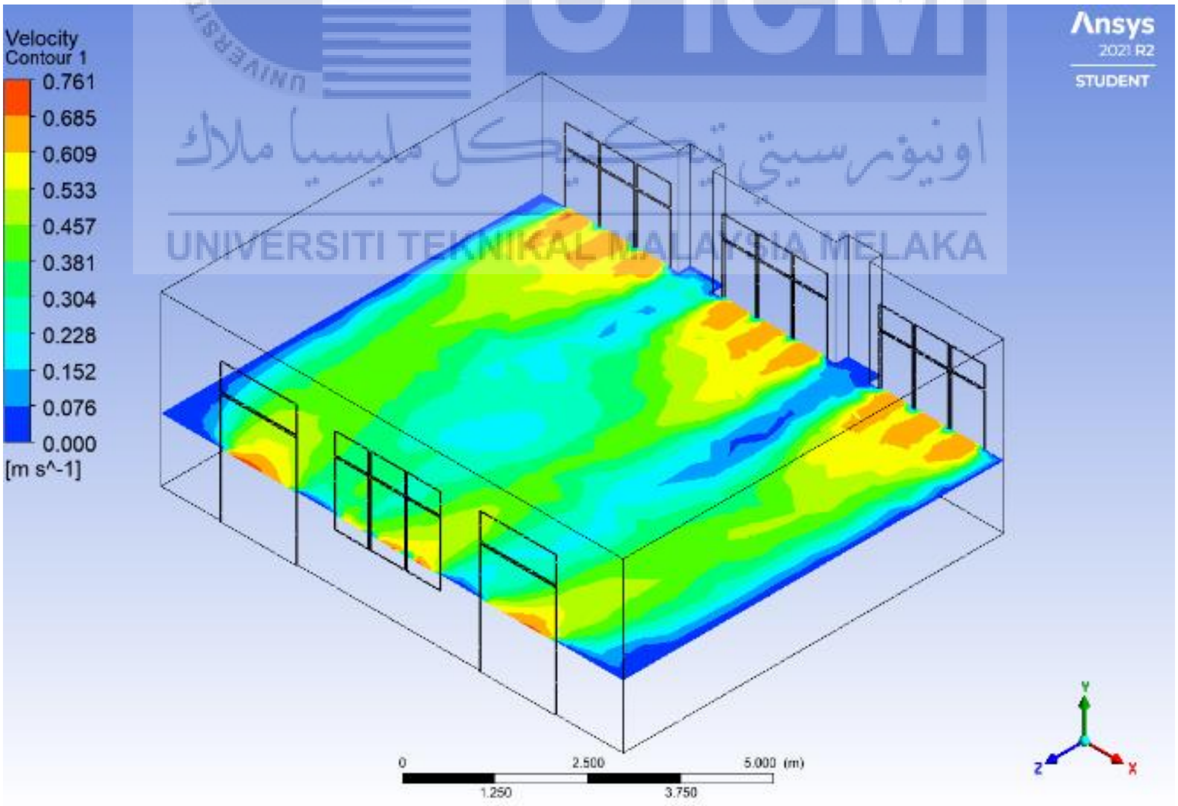


Figure 4.14 Contour view 2 first floor (no tent)

Figure 4.15 and Figure 4.16 show a streamline view, and Figure 4.17 and Figure 4.18 show a contour view of the class to which the tent has been installed. Description of incoming wind flow starting from windows 2, 3, 4 and through tent 1 and tent 2 before exiting through door 1, door 2, and window 1 with wind speeds between 0.00m/s to 0.791 m/s. And the wind speed inside the tent showed readings between 0.00 m/s to 0.554 m/s, and the average is 0.28 m/s.

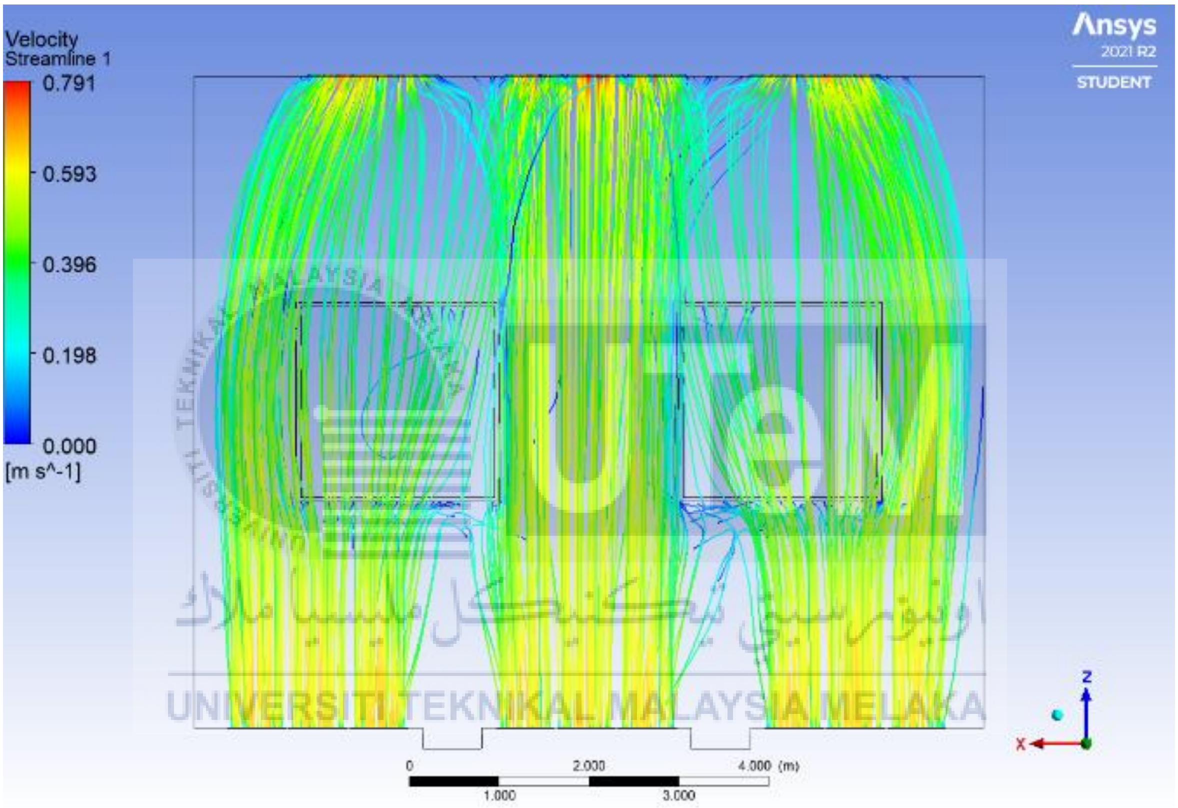


Figure 4.15 Streamline view 1 first floor (included tent)

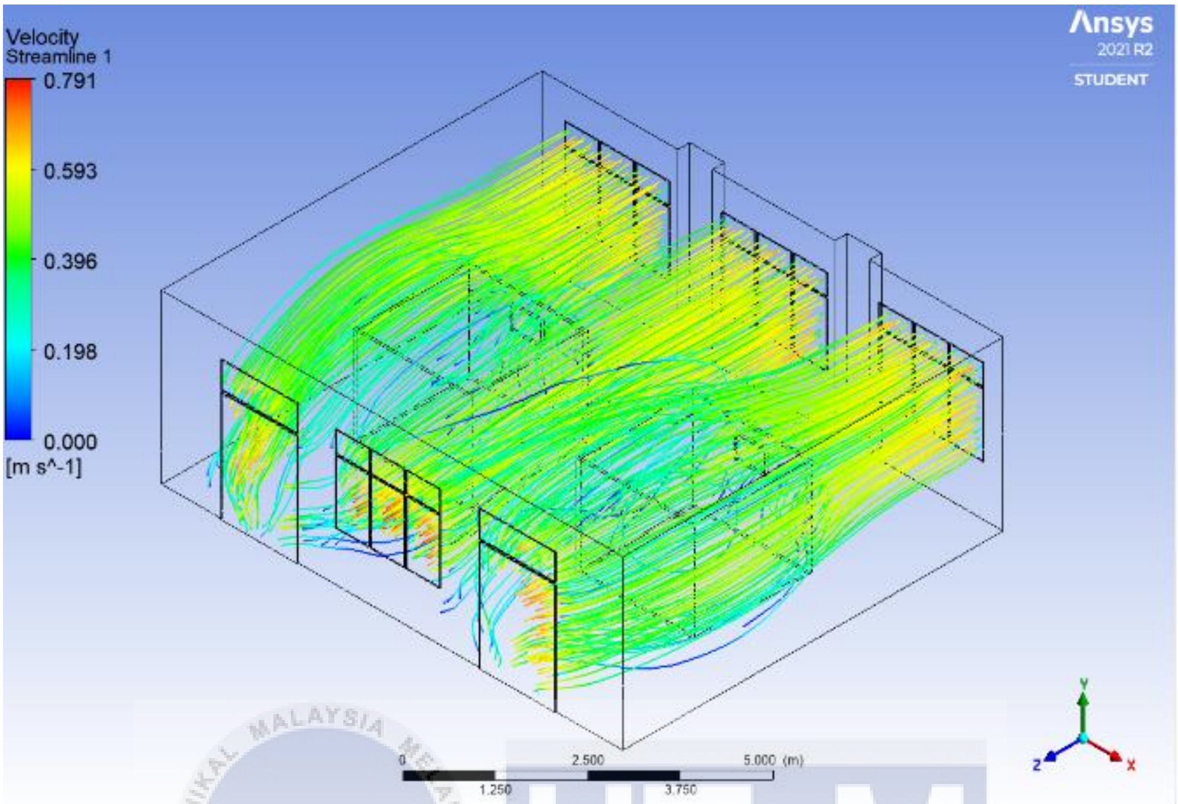


Figure 4.16 Streamline view 2 first floor (included tent)

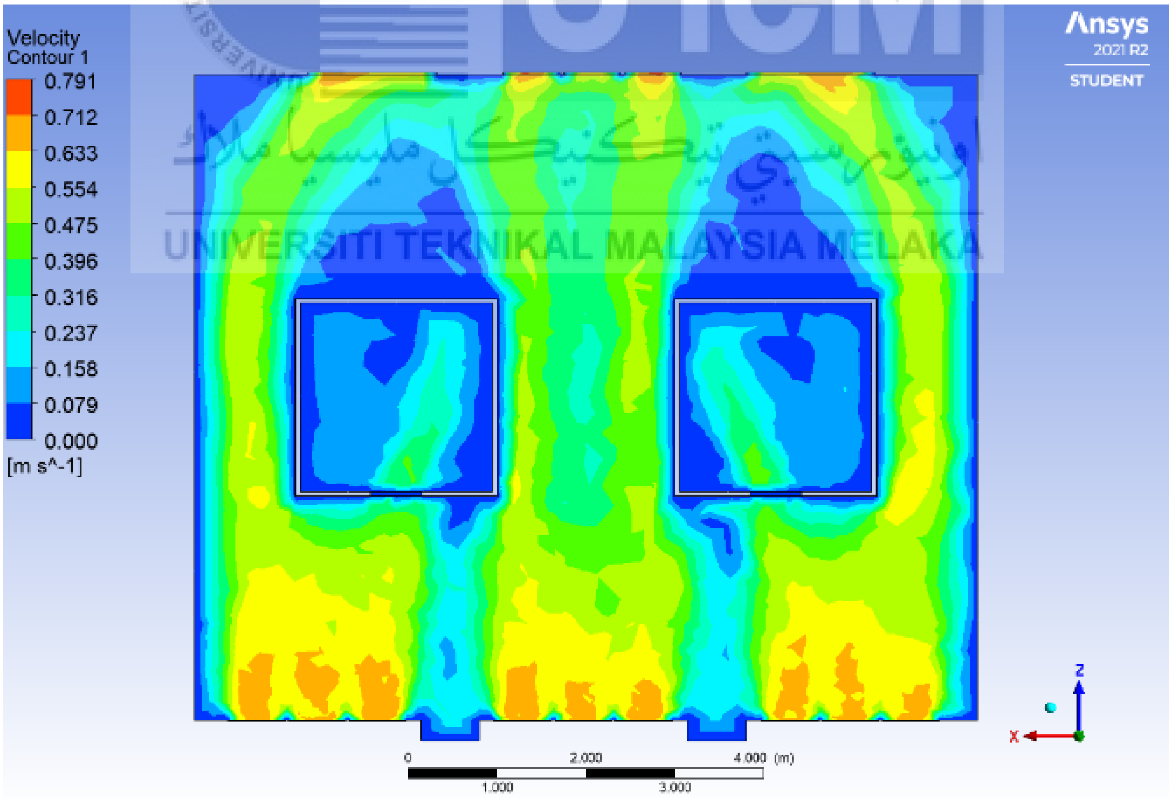


Figure 4.17 Contour view 1 first floor (included tent)

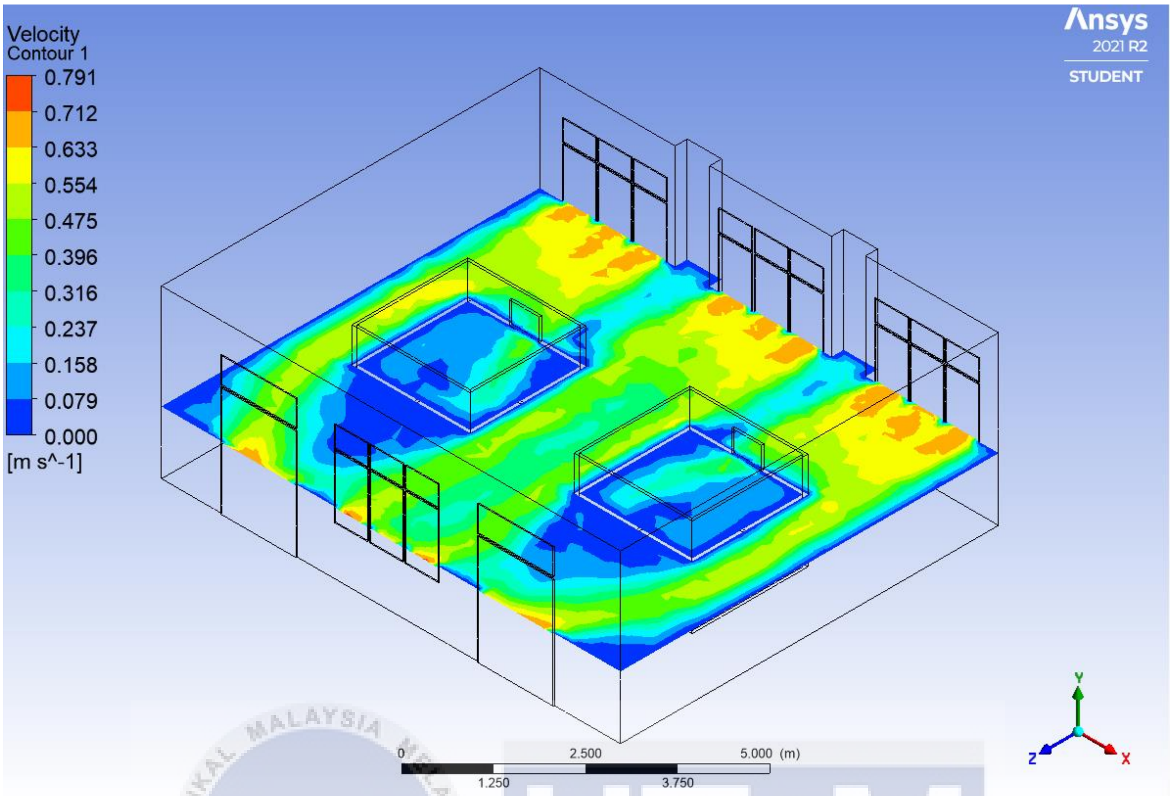


Figure 4.18 Contour view 2 first floor (included tent)

4.3.3 Second floor

Figure 4.19 and Figure 4.20 show a streamline view, and Figure 4.21 and Figure 4.22 show a contour view of the wind velocity of a class that is not tented. The wind flow picture starts from windows 2, 3, 4 and continues to door 1, door 2, and window 1 with wind speeds between 0.00 m/s to 1,586 m/s. And the centre of the building wind speed is between 0.159 m/s to 1.110 m/s, and the average wind speed at the centre is 0.63 m/s.

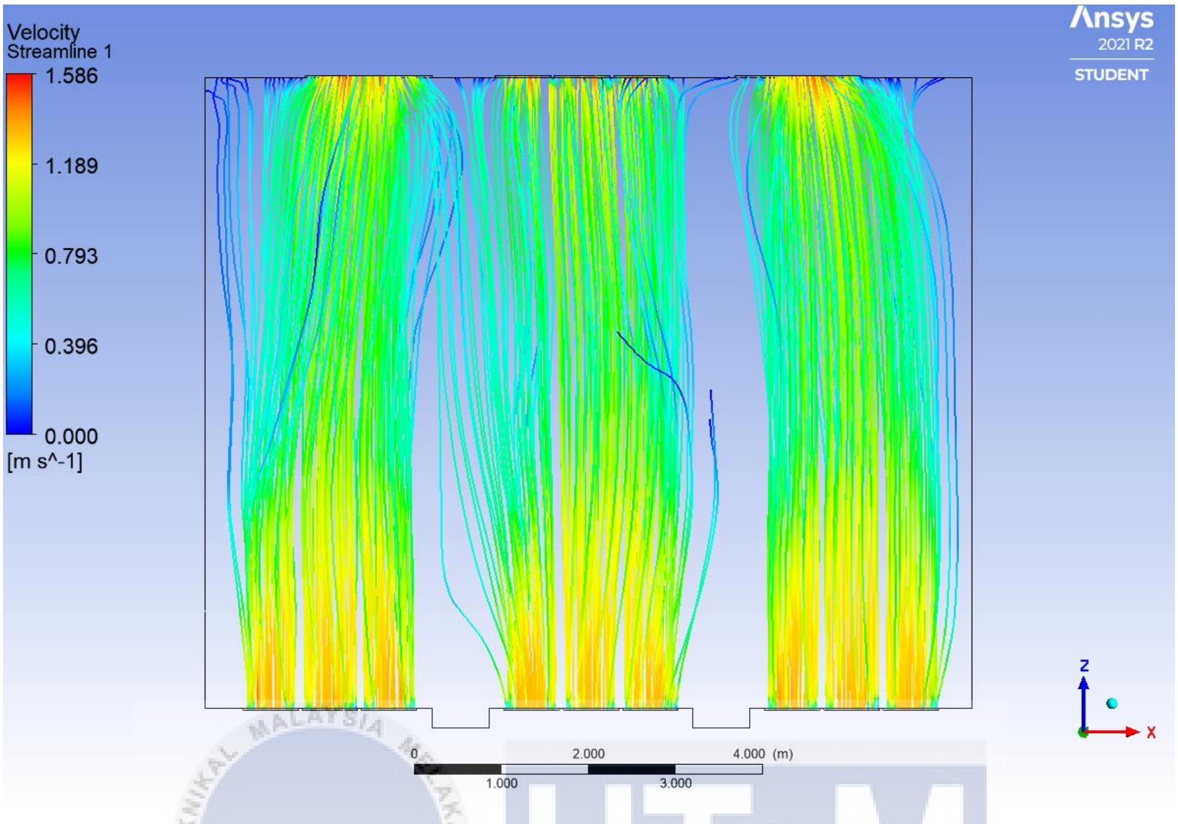


Figure 4.19 Streamline view 1 second floor (no tent)

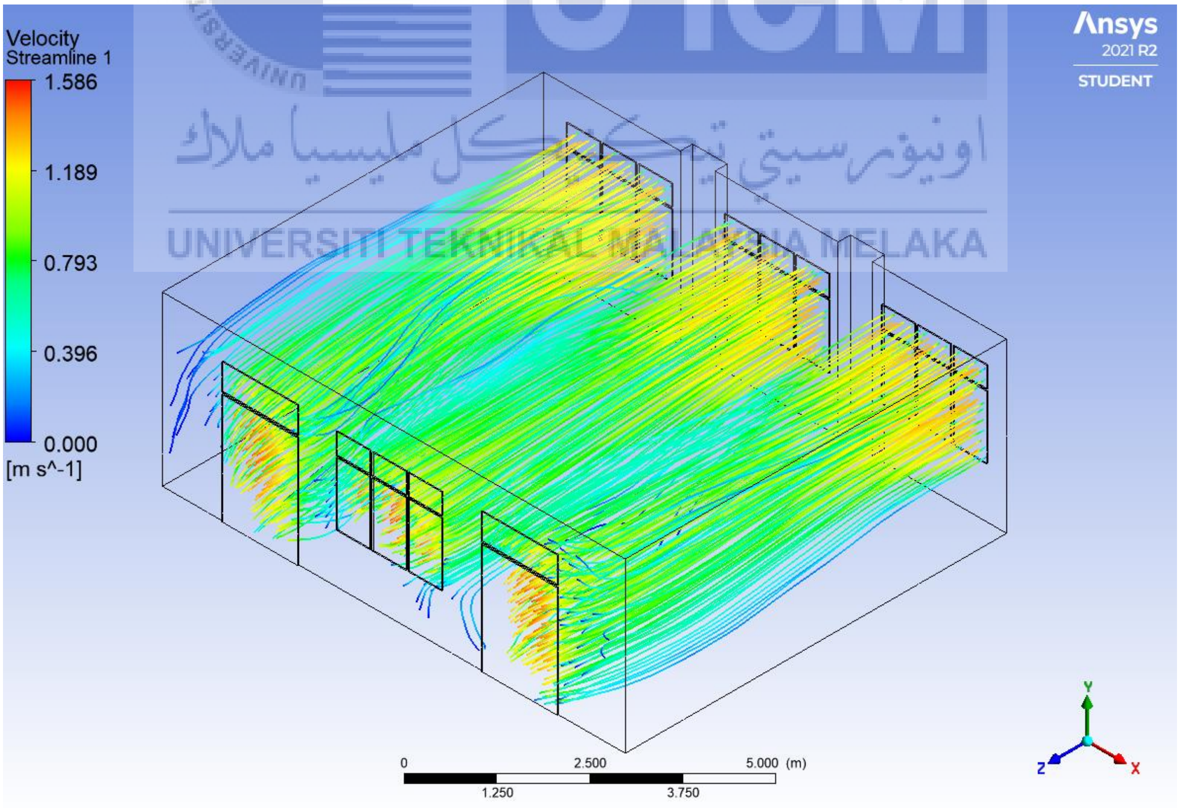


Figure 4.20 Streamline view 2 second floor (no tent)

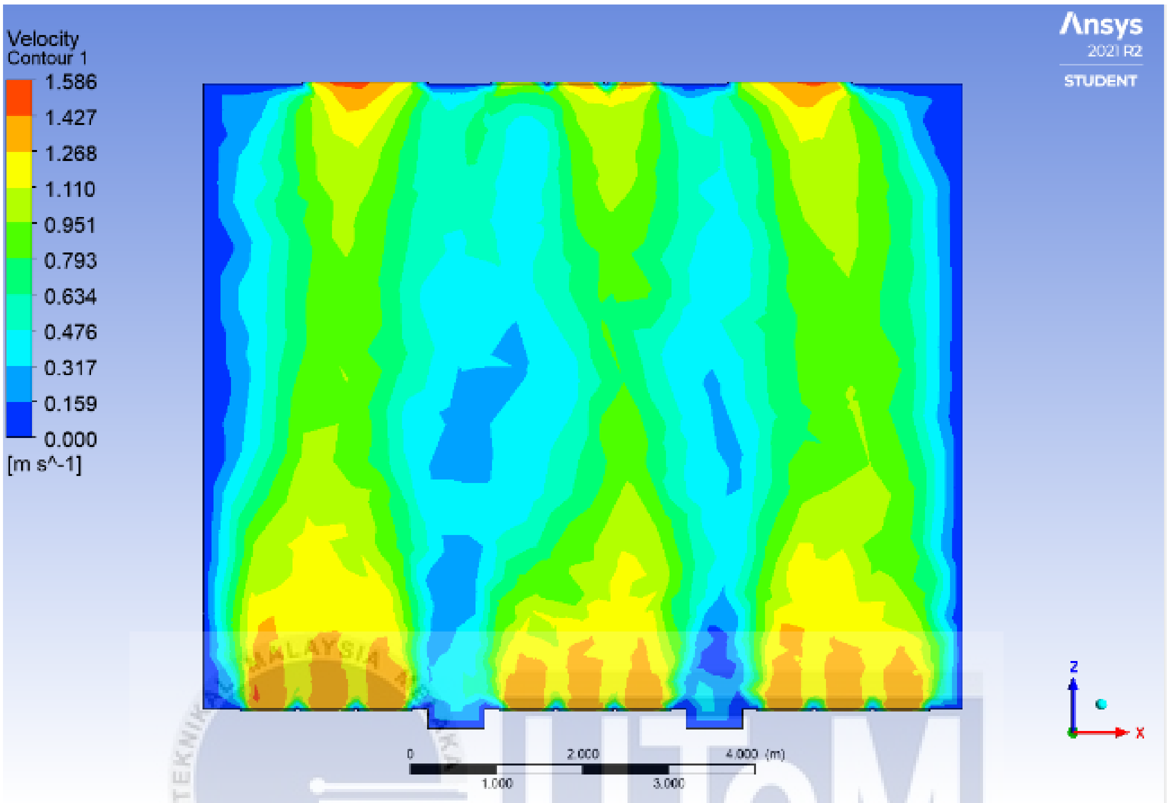


Figure 4.21 Contour view 1 second floor (no tent)

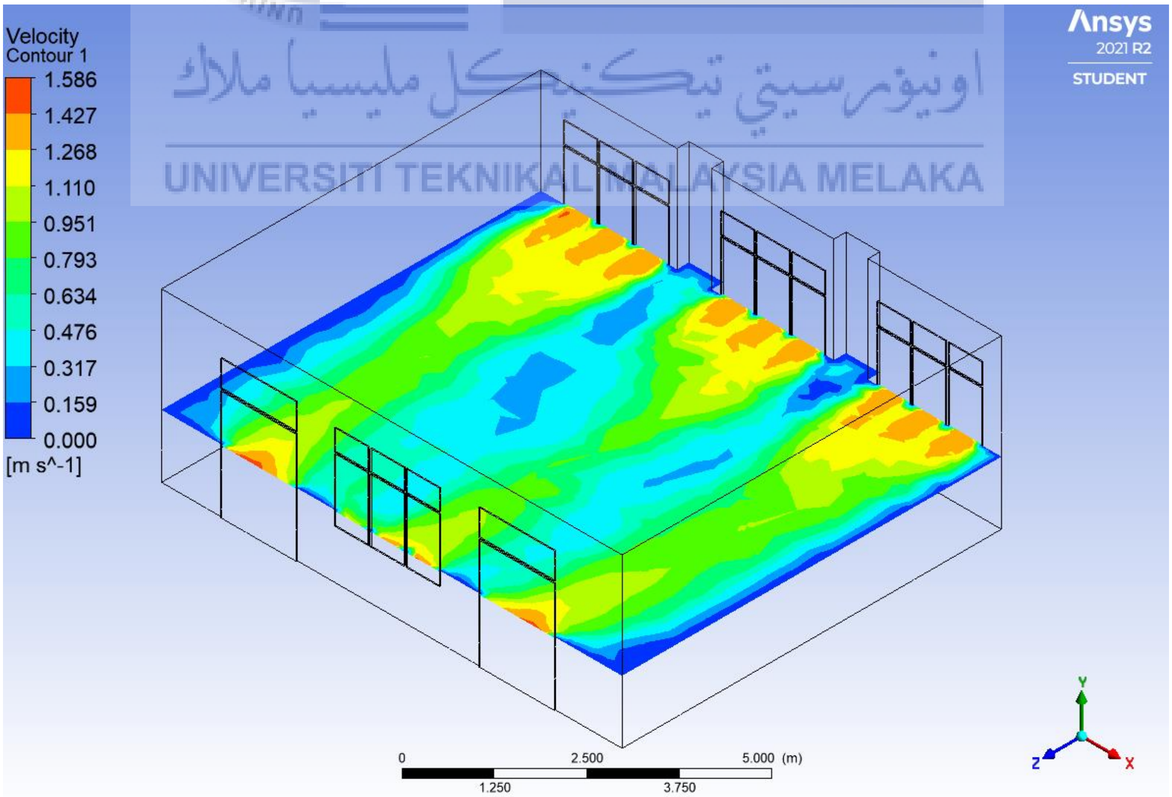


Figure 4.22 Contour view 2 second floor (no tent)

Figure 4.23 and Figure 4.24 show a streamline view, and Figure 4.25 and Figure 4.26 show a contour view of the wind velocity of the class to which the tent has been installed. The incoming wind flow starts from windows 2, 3, 4 and through tent 1 and tent 2 before exiting through door 1, door 2, and window 1 with wind speeds between 0.00 m/s to 1.697 m/s. And the wind speed inside the tent showed readings between 0.00 m/s to 1.188 m/s, and the average is 0.59 m/s.

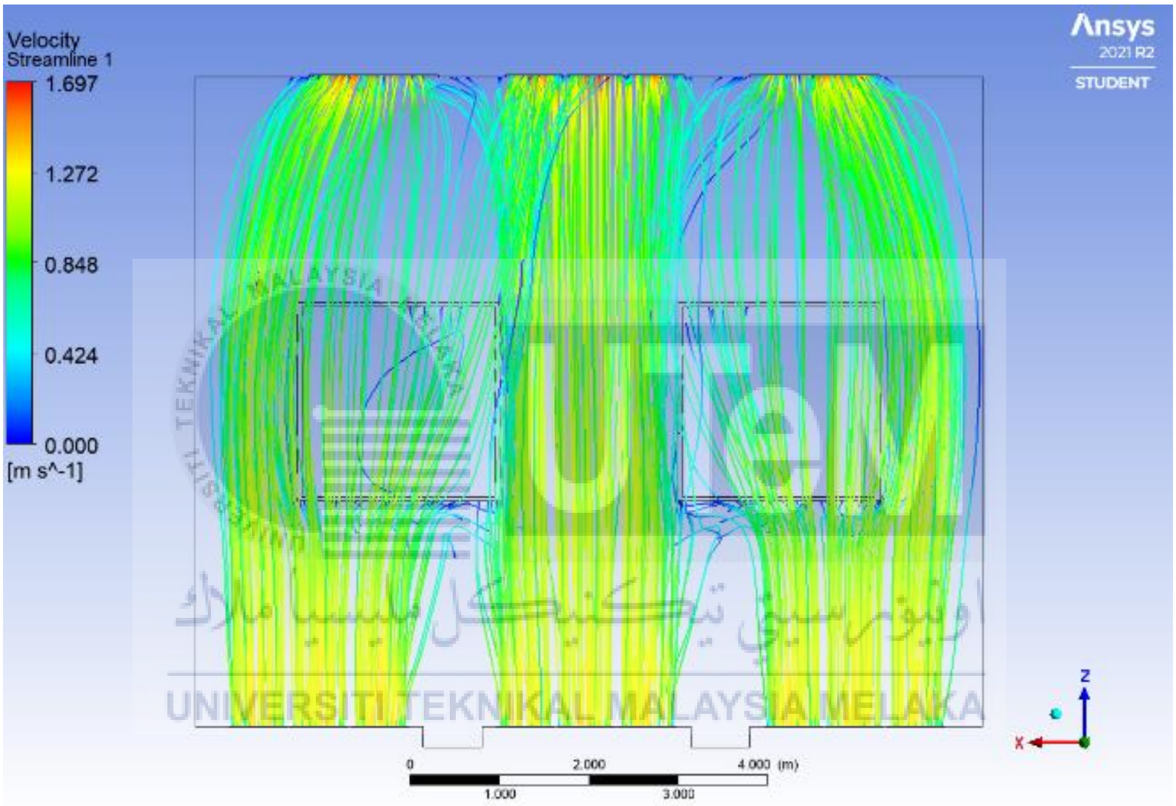


Figure 4.23 Streamline view 1 second floor (included tent)

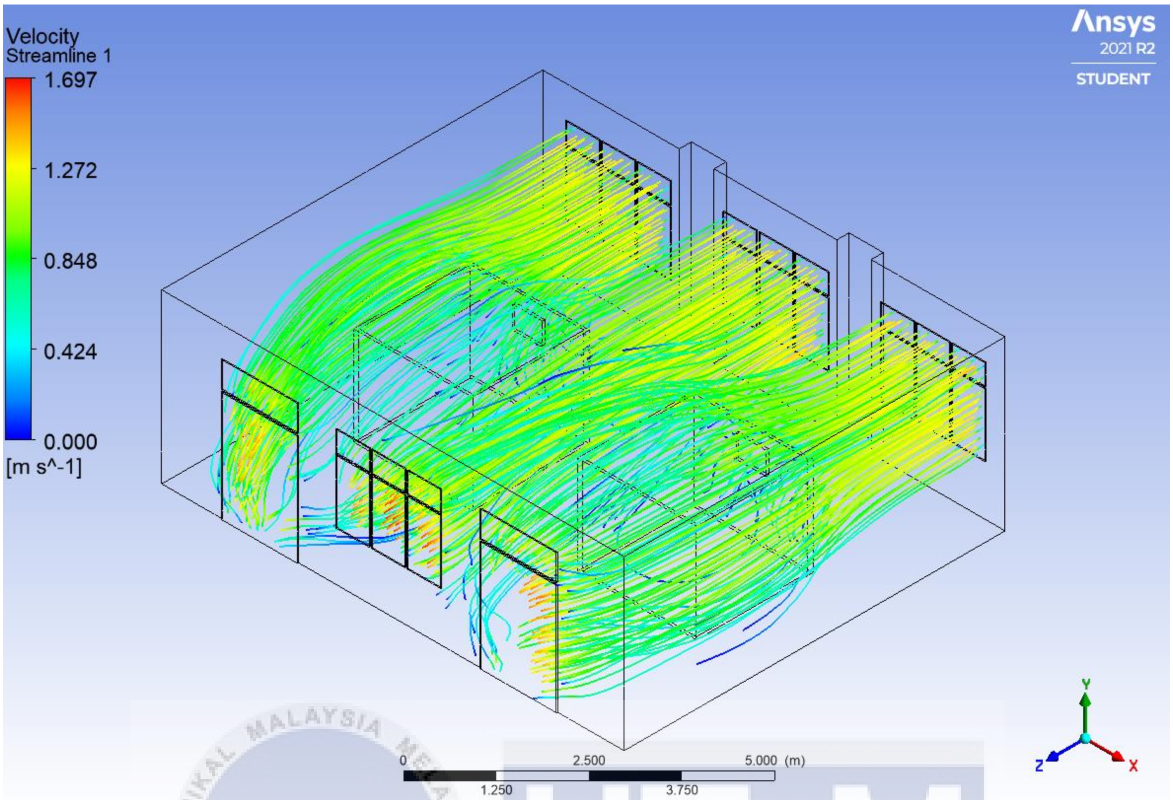


Figure 4.24 Streamline view 2 second floor (included tent)

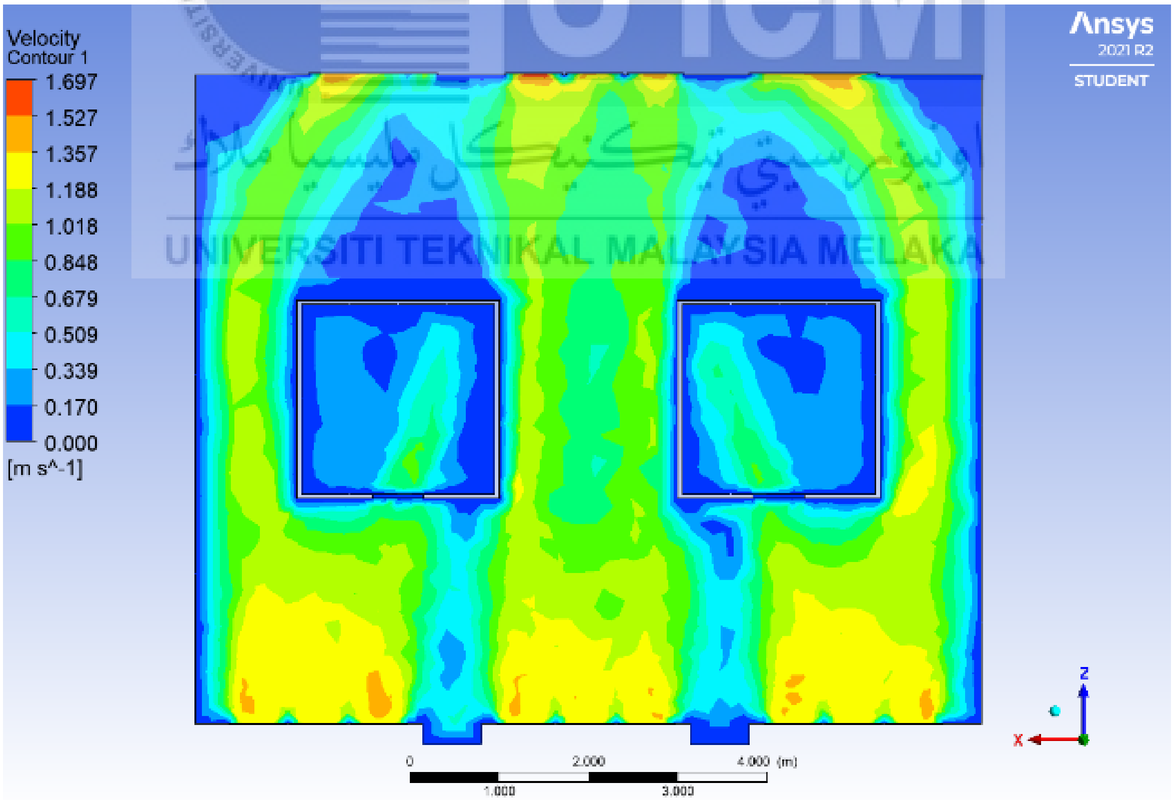


Figure 4.25 Contour view 1 second floor (included tent)

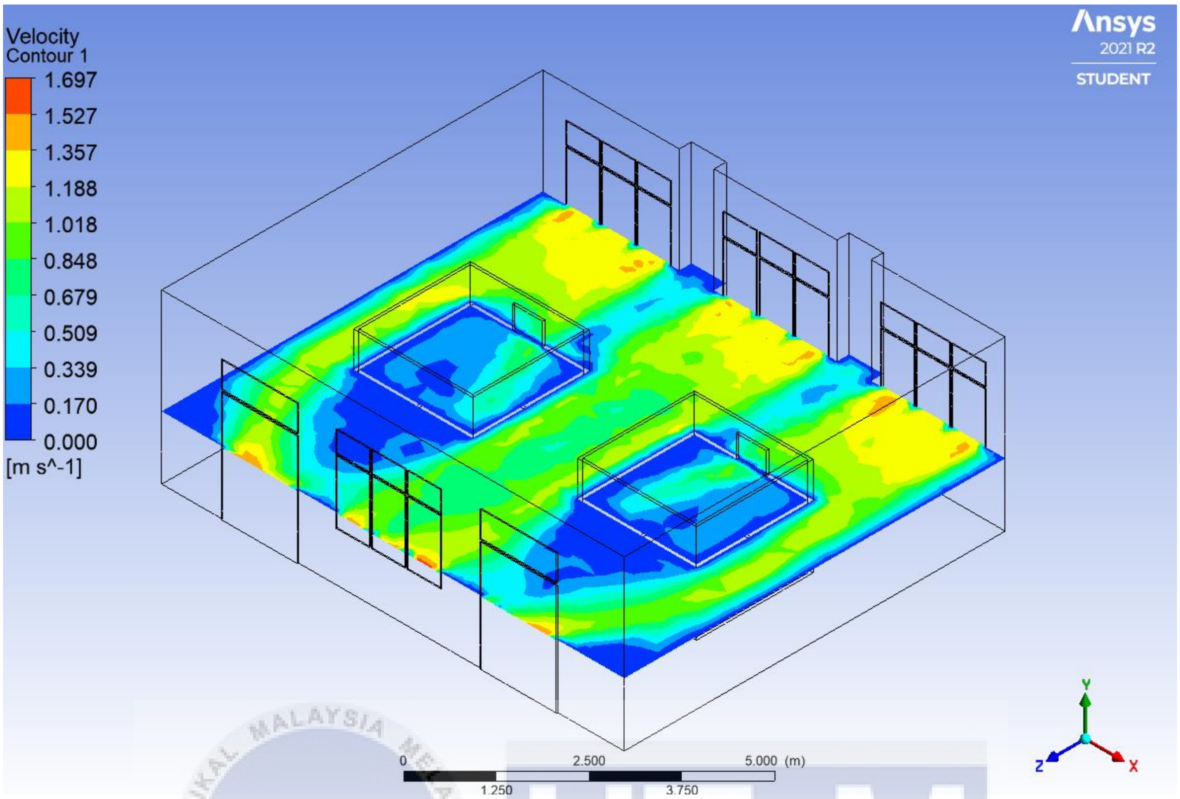


Figure 4.26 Contour view 2 second floor (included tent)

4.4 Discussion

Wind movement in all three classes is cross-ventilation, where the wind through directly from east to west opening. The wind that enters the three classes used as evacuation centres is faster from the east, and this is due to the position of the class on the three floors where window 2, window 3, and window 4 face east. To the east of the classroom is a school field, and there is no obstacle for the wind to continue to flow and enter the classroom. On the west side, the cause of the slow wind from that direction is because the next building block covers the winding path. Therefore, the incoming wind is too slow and less than from the east.

Next, different heights show different wind speeds, as shown in the airflow simulation where the average wind on the ground floor is 0.47 m/s which is the slowest, and the evacuation centre on the first floor is 0.64 m/s. And the highest evacuation centre is on the second floor, and the wind speed is 1.33 m/s. So the second flow wind speed is 48.12% faster than the first flow and 35.34% faster than the ground floor.

The installation of a tent in the classroom will result in a reduction in wind speed. All three simulations in the classroom showed a decrease in the wind after installing the tent. This is because the source of wind that enters the tent is only through a wind channel located behind the tent's entrance. The tent wind duct faces directly into the inflow causing the wind to enter through the wind duct.

Based on the simulation, the results shown when the evacuation centre is not tented are as follows for the ground floor and, first, floor shows the wind speed in the central area of the evacuation centre is still within limits set by DOSH. The average readings on the ground floor and first floor are 0.28 m/s and 0.34 m/s. This wind speed is suitable for occupants in evacuation centres because this speed is still within the limits of 0.15 m/s to 0.5 m/s. And for the second floor, the wind speed in the middle of the evacuation centre is above the DOSH limit, which is 0.63 m/s. Therefore, for the second floor, the wind exceeds the limit set by the dosh and will cause discomfort to the occupant. Chances are, the occupant will feel a little cold and uncomfortable because the wind is too strong.

The wind speed simulation of the evacuation centre installed by the Tent showed a reduction in the wind at all three-floor levels. For the ground floor, the wind in the tent does not reach the DOSH standard because the average wind speed on the ground floor is only 0.14 m/s. These can cause discomfort to the occupant inside the tent. And for the first floor, although the reduction in velocity occurs on this floor, the simulation results show that the average wind speed on the floor is still within the limit of 0.277 m/s. And the last one is the wind speed in the tent on the second floor. The simulation of wind velocity in the second floor tent is above DOSH standards. Although there was a reduction in the show after the tent was set up, the wind inside the tent still exceeded 0.5 m/s. This will cause the occupant in the area to feel uncomfortable.

In turn, capacity reduction at flood evacuation centres can help occupants get comfort in spaces with less wind movement. For example, the limit of one tent can accommodate 4 to 5 people. For less windy floor levers, it may be possible to reduce one more person to comfort the tent. And the second floor is suitable to accommodate five people in the tent. Next, using a fan can help provide comfort to the occupant in a hot area. Since this study only uses the nature of airflow, this method is somewhat helpful in achieving the set DOSH limit to get more comfortable. And for a floor lever with a stronger airflow, wearing thicker clothes can reduce the current cold in the evacuation centre area.

4.5 Summary

In this chapter, we have explained why the wind speed will increase if the height of an area is higher. The area or atmosphere of an Area also plays an important role in contributing to this area's ventilation. In this study, the simulations show the wind speed difference if the tent installation is done. The tent also plays a role in whether it helps in terms of getting the ideal speed or vice versa. In short, some Areas require the installation of tents, and some areas do not need tents to get proper comfort. With this simulation, all the problems encountered can be solved easily, and with this simulation, the selection of tent installation can also be selected correctly.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

For this chapter, conclusions and recommendations for evacuation centres will be prepared based on the data obtained, data collection and simulations will be conducted. Air distribution at the evacuation centre will follow the standards set by DOSH.

5.2 Conclusion

In conclusion, many residents of flood evacuation centres complain of feeling hot while in the evacuation centre. This is because the airflow in the evacuation is very poor. Therefore, they feel uncomfortable, which is a concern if they have small children. With the study of air distribution in this evacuation, this research has found problem-solving encountered while in the evacuation centre. However, this study has a limited scope, among which is that this study was conducted in schools building around Melaka only.

The monitoring of three different floor levers in one of the evacuation centres operating in Melaka shows that building height plays a vital role in wind speed. The second floor data shows that the air velocity is the highest. That is, the average wind is 1.33 m/s. And the average first-floor wind speed is 0.64 m/s. And the lowest is on the ground floor, where the average wind is 0.47 m/s. Therefore, with the available data, I can conclude that the wind will increase if the height of the building gets higher.

Next, the study aimed to compare the airflow in the evacuation centre area using simulation software. From the simulation, I can conclude that the ground floor is very suitable if the tent is not installed in the classroom. This is because the wind speed in the tent is 0.14 m/s which is not within the DOSH limit range. Therefore, ventilation on the ground floor is only suitable for residents who do not care about privacy in the evacuation centre. Because the wind in the centre of the classroom is at an average of 0.28 m/s, In that case, the occupants of the evacuation centre on the ground floor should turn on the fan or portable air conditioner to get comfortable while in the evacuation centre. Next is the first floor. The simulation shows both conditions, namely included a tent and a not included tent on the first-floor level. The velocity is reasonable and still within the DOSH limit, 0.28 m/s and 0.34 m/s. And the last one is on the second floor. For both conditions, namely, including a tent and not using a tent, the data from the simulation shows that the data is over the limit of DOSH which is 0.59 m/s and 0.63 m/s. Because both of these conditions show high readings on both states, wearing thicker clothes is the best recommendation for occupants on the second-floor level. This is to reduce the cold during in the evacuation centre. In this way, the comfort of the occupants in the flood evacuation centre can be overcome.

With this study, the social welfare department (JKM) can improve placement by arranging floor levels according to occupant wishes. Furthermore, because the arrangement is according to what the occupant wants, it will reduce complaints about the comfort at the flood evacuation centre.

5.3 Recommendation

For the recommendation, there are things I would like to suggest to future researchers, and this will probably be able to improve the airflow in the flood evacuation centre, including:

i) Studies can be conducted in buildings other than school buildings, such as halls or community halls.

ii) Make comparisons between classrooms or halls that are most suitable for evacuation centres.

iii) Data collection done more than one day is the best data.

iv) When meshing the simulation in the Ansys software, use a more fine cell size to get the accuracy in the simulation.

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APPENDICES

APPENDIX A Gantt Chart final year project 1

TASK DESCRIPTION	YEAR	2021																
	MONTH	MARCH			APRIL				MAY				JUNE				JULY	
	WEEK		1	2	3	4	5	6	7	Sem. Break	8	9	10	11	12	13	14	
Choose a supervisor																		
Decide the project & concept																		
Planning																		
Sketch out ideas																		
Plan review																		
Proposal Project																		
Concept descriptions																		
Further research on evacuation centres problem																		
Research analysis review																		
Study flood location and Airflow distribution in evacuation centres																		

APPENDIX A (Cont.) Gantt Chart final year project 1

Introduction of Airflow distribution in evacuation centres																		
Airflow distribution in evacuation centres Literature Review																		
Airflow distribution in evacuation centres Methodology																		
Preparation of presentation																		
Preparation of finalizing proposal report																		
Submission of finalized proposal report																		
Presentation of PSM 1																		

APPENDIX BGantt Chart final year project 2

TASK DESCRIPTION	YEAR	2021													2022	
	MONTH	October				November				December					January	
	WEEK	1	2	3	4	5	6	7	8	9	10	11	12	Disaster leave	13	14
Addition of material in chapters 1, 2, 3																
Research and provide methods																
The application process for approval from Educational Research Application (eRAS)																
Application for approval from the Melaka State Education Department to conduct research																
Make an application to so a research SMK Bukit Katil study																
Preparation equipment																
Data collection at the site																

APPENDIX B(Cont.) Gantt Chart final year project 2

Draw SolidWorks 3d design and Simulation airflow in evacuation centre (3 floor level)																	
Discussion result simulation																	
Preparation of presentation																	
Preparation of finalizing proposal report																	
Submission of finalized thesis																	
Presentation of PSM 2																	

APPENDIX C Data velocity and temperature class 5 Akaun (ground floor)

5 Akaun	Velocity							Temperature						
Time	D1	D2	W1	W2	W3	W4	Average	D1	D2	W1	W2	W3	W4	Average
8:00	0.25	0.25	0	0.92	0.84	0.78	0.51	27.6	27.6	27.6	27.6	27.6	27.6	27.6
8:30	0.25	0	0.35	0.92	0.88	0.88	0.55	27.7	27.7	27.7	27.7	27.7	27.7	27.7
9:00	0.33	0.36	0.33	0.4	0.45	0.35	0.37	27.8	27.8	27.8	27.8	27.8	27.8	27.8
9:30	0.41	0.25	0.47	0.35	0.4	0.42	0.38	28.8	28.8	28.8	28.8	28.8	28.8	28.8
10:00	0.41	0.35	0.25	0.7	0.68	0.75	0.52	27.9	27.9	27.9	27.9	27.9	27.9	27.9
10:30	0.65	0.5	0.7	0.78	0.4	0.25	0.55	27.8	27.8	27.8	27.8	27.8	27.8	27.8
11:00	0.45	0.54	0.49	0.45	0.5	0.5	0.49	27.9	27.9	27.9	27.9	27.9	27.9	27.9
11:30	0.66	0.5	0.57	0.46	0.6	0.67	0.58	28.2	28.2	28.2	28.2	28.2	28.2	28.2
12:00	0.65	0.35	0.35	1.43	1	0.98	0.79	30.2	30.2	30.2	30.2	30.2	30.2	30.2
12:30	0.7	0.65	0.55	1.42	1.05	1.06	0.91	30.1	30.1	30.1	30.1	30.1	30.1	30.1
13:00	0.68	0.68	0.74	1.03	0.98	0.25	0.73	30.6	30.6	30.6	30.6	30.6	30.6	30.6
13:30	0.75	0.75	0.6	1.3	1.35	1.47	1.04	30.9	30.9	30.9	30.9	30.9	30.9	30.9
14:00	0.7	0.68	0.74	1.4	0.99	1.02	0.92	31	31	31	31	31	31	31
14:30	0.63	0.67	0.5	1.25	0.45	0.82	0.72	31.1	31.1	31.1	31.1	31.1	31.1	31.1
15:00	0.5	0.35	0.29	1	1.7	0.7	0.76	31.2	31.2	31.2	31.2	31.2	31.2	31.2
15:30	0.6	0.52	0.6	0.98	0.81	1	0.75	29.6	29.6	29.6	29.6	29.6	29.6	29.6
16:00	0.71	0.6	0.7	0.99	0.8	0.98	0.80	29.2	29.2	29.2	29.2	29.2	29.2	29.2
16:30	0.6	0.45	0.44	0.62	0.7	0.8	0.60	29.1	29.1	29.1	29.1	29.1	29.1	29.1
17:00	0.25	0.25	0.51	0.54	0.5	0.4	0.41	29	29	29	29	29	29	29
17:30	0.25	0.35	0.25	0.35	0.36	0.5	0.34	29	29	29	29	29	29	29
18:00	0	0.4	0.26	0.35	0.34	0.34	0.28	28.8	28.8	28.8	28.8	28.8	28.8	28.8
18:30	0.25	0	0.3	0.4	0.3	0.35	0.27	27.9	27.9	27.9	27.9	27.9	27.9	27.9
19:00	0.32	0.36	0.44	0.5	0.55	0.55	0.45	27.5	27.5	27.5	27.5	27.5	27.5	27.5
19:30	0.41	0.27	0.44	0.5	0.4	0.75	0.46	27.3	27.3	27.3	27.3	27.3	27.3	27.3
20:00	0.35	0.48	0.28	0.8	0.6	0.47	0.50	27.1	27.1	27.1	27.1	27.1	27.1	27.1
20:30	0.35	0.47	0.5	0.74	0.4	0.5	0.49	27	27	27	27	27	27	27
21:00	0	0.3	0.26	0.6	0.77	0.7	0.44	26.3	26.3	26.3	26.3	26.3	26.3	26.3
21:30	0.4	0.25	0.35	0.59	0.35	0.48	0.40	26.4	26.4	26.4	26.4	26.4	26.4	26.4
22:00	0.4	0.3	0.35	0.45	0.4	0.25	0.36	26.4	26.4	26.4	26.4	26.4	26.4	26.4
22:30	0.25	0.25	0.44	0.62	0.5	0.52	0.43	26.4	26.4	26.4	26.4	26.4	26.4	26.4
23:00	0.35	0.42	0.5	0.35	0.25	0.3	0.36	26.2	26.2	26.2	26.2	26.2	26.2	26.2
23:30	0.25	0.35	0.6	0.35	0.35	0.3	0.37	26.2	26.2	26.2	26.2	26.2	26.2	26.2
0:00:00	0	0.25	0.41	0.37	0.44	0.5	0.33	26.1	26.1	26.1	26.1	26.1	26.1	26.1
0:30	0.25	0.25	0.25	0.41	0.42	0.47	0.34	25	25	25	25	25	25	25
1:00	0.26	0.25	0.25	0.25	0.35	0.45	0.30	25.2	25.2	25.2	25.2	25.2	25.2	25.2
1:30	0.25	0.35	0.3	0.26	0.28	0.3	0.29	25	25	25	25	25	25	25
2:00	0	0.34	0.25	0.25	0.3	0.45	0.27	25.2	25.2	25.2	25.2	25.2	25.2	25.2
2:30	0.4	0.39	0	0.35	0.5	0.65	0.38	25	25	25	25	25	25	25
3:00	0.35	0	0.33	0.41	0.25	0.35	0.28	25	25	25	25	25	25	25
3:30	0.25	0.25	0.5	0.35	0.4	0.55	0.38	25.2	25.2	25.2	25.2	25.2	25.2	25.2
4:00	0.3	0.3	0.41	0.25	0.35	0.25	0.31	25	25	25	25	25	25	25
4:30	0.25	0.27	0.33	0.25	0.65	0.25	0.33	24.8	24.8	24.8	24.8	24.8	24.8	24.8
5:00	0	0.26	0.25	0.39	0.41	0.36	0.28	24.8	24.8	24.8	24.8	24.8	24.8	24.8
5:30	0.25	0.25	0.26	0.3	0.45	0.3	0.30	24.9	24.9	24.9	24.9	24.9	24.9	24.9
6:00	0.3	0.33	0.36	0.34	0.33	0.47	0.36	24.7	24.7	24.7	24.7	24.7	24.7	24.7
6:30	0.35	0.25	0	0.4	0.41	0.44	0.31	24.5	24.5	24.5	24.5	24.5	24.5	24.5
7:00	0.25	0.45	0.25	0.6	0.7	0.58	0.47	24.1	24.1	24.1	24.1	24.1	24.1	24.1
7:30	0.35	0.25	0.4	0.45	0.5	0.28	0.37	24.5	24.5	24.5	24.5	24.5	24.5	24.5
8:00	0.78	0.4	0.33	0.39	0.43	0.37	0.45	25.2	25.2	25.2	25.2	25.2	25.2	25.2
							0.47							27.2

APPENDIX D Data velocity and temperature class 2 Arif (first floor)

2 Arif	Velocity							Temperature						
Time	D1	D2	W1	W2	W3	W4	Average	D1	D2	W1	W2	W3	W4	Average
8:00	0.35	0.52	0.45	0.93	0.98	1.4	0.77	27.4	27.4	27.4	27.4	27.4	27.4	27.4
8:30	0.34	0.45	0.37	0.85	0.74	1.03	0.63	27.8	27.8	27.8	27.8	27.8	27.8	27.8
9:00	0.51	0.45	0.38	0.84	0.74	0.88	0.63	27.8	27.8	27.8	27.8	27.8	27.8	27.8
9:30	0.34	0.39	0.45	0.63	0.74	0.65	0.53	28.4	28.4	28.4	28.4	28.4	28.4	28.4
10:00	0.37	0.37	0.36	0.8	1.25	0.89	0.67	27.8	27.8	27.8	27.8	27.8	27.8	27.8
10:30	0.51	0.36	0.5	0.74	0.72	0.74	0.60	27.9	27.9	27.9	27.9	27.9	27.9	27.9
11:00	0.45	0.4	0.39	0.74	0.98	0.99	0.66	27.8	27.8	27.8	27.8	27.8	27.8	27.8
11:30	0.85	0.65	0.5	0.94	0.7	0.94	0.76	28.1	28.1	28.1	28.1	28.1	28.1	28.1
12:00	0.7	0.65	0.5	1.24	0.98	1.25	0.89	30.1	30.1	30.1	30.1	30.1	30.1	30.1
12:30	1.07	1.3	0.93	0.87	1.04	0.99	1.03	30.1	30.1	30.1	30.1	30.1	30.1	30.1
13:00	1.03	1.08	1	1.21	0.98	0.98	1.05	30.5	30.5	30.5	30.5	30.5	30.5	30.5
13:30	1.07	1.45	1.43	1.44	1.02	1.21	1.27	30.8	30.8	30.8	30.8	30.8	30.8	30.8
14:00	1.08	1.52	1.35	1.32	1.25	1.36	1.31	31	31	31	31	31	31	31
14:30	1.08	0.98	0.98	1.46	1.5	1.52	1.25	31.1	31.1	31.1	31.1	31.1	31.1	31.1
15:00	0.98	0.87	0.78	1.77	1.08	1.05	1.09	31.2	31.2	31.2	31.2	31.2	31.2	31.2
15:30	0.99	0.78	1.07	1.43	1.45	1.46	1.20	29.6	29.6	29.6	29.6	29.6	29.6	29.6
16:00	1	1.03	1.04	1.48	1.2	1.3	1.18	29.2	29.2	29.2	29.2	29.2	29.2	29.2
16:30	0.98	0.99	1.45	0.93	0.75	0.78	0.98	29.1	29.1	29.1	29.1	29.1	29.1	29.1
17:00	0.5	0.65	0.53	0.9	0.85	0.85	0.71	29.1	29.1	29.1	29.1	29.1	29.1	29.1
17:30	0.4	0.3	0.35	0.55	0.45	0.74	0.47	29	29	29	29	29	29	29
18:00	0.42	0.45	0.43	0.49	0.52	0.65	0.49	28.8	28.8	28.8	28.8	28.8	28.8	28.8
18:30	0.46	0.45	0.4	0.93	0.75	0.74	0.62	27.8	27.8	27.8	27.8	27.8	27.8	27.8
19:00	0.53	0.25	0.35	0.8	0.84	0.75	0.59	27.5	27.5	27.5	27.5	27.5	27.5	27.5
19:30	0.6	0.67	0.56	0.75	0.45	0.5	0.59	27.3	27.3	27.3	27.3	27.3	27.3	27.3
20:00	0.5	0.49	0.47	0.93	0.78	0.82	0.67	27	27	27	27	27	27	27
20:30	0.4	0.43	0.41	0.65	0.7	0.68	0.55	27	27	27	27	27	27	27
21:00	0.43	0.43	0.36	0.65	0.62	0.73	0.54	26.3	26.3	26.3	26.3	26.3	26.3	26.3
21:30	0.36	0.4	0.41	0.55	0.55	0.57	0.47	26.1	26.1	26.1	26.1	26.1	26.1	26.1
22:00	0.44	0.44	0.52	0.25	0.34	0.35	0.39	26.2	26.2	26.2	26.2	26.2	26.2	26.2
22:30	0.52	0.41	0.45	0.71	0.61	0.61	0.55	26.2	26.2	26.2	26.2	26.2	26.2	26.2
23:00	0.4	0.39	0.23	0.52	0.47	0.48	0.42	26.2	26.2	26.2	26.2	26.2	26.2	26.2
23:30	0.52	0.39	0.35	0.42	0.45	0.31	0.41	26.2	26.2	26.2	26.2	26.2	26.2	26.2
0:00:00	0.35	0.34	0.35	0.62	0.4	0.35	0.40	26	26	26	26	26	26	26
0:30:00	0.36	0.36	0.26	0.5	0.35	0.45	0.38	25	25	25	25	25	25	25
1:00	0.41	0.42	0.44	0.4	0.45	0.56	0.45	25	25	25	25	25	25	25
1:30	0.25	0.25	0.25	0.56	0.7	0.75	0.46	25	25	25	25	25	25	25
2:00	0.6	0.52	0.48	0.47	0.45	0.25	0.46	25	25	25	25	25	25	25
2:30	0.45	0.48	0.47	0.5	0.35	0.35	0.43	25	25	25	25	25	25	25
3:00	0.25	0.3	0.52	0.25	0.37	0.25	0.32	25	25	25	25	25	25	25
3:30	0.56	0.49	0.37	0.43	0.48	0.56	0.48	25.1	25.1	25.1	25.1	25.1	25.1	25.1
4:00	0.41	0.42	0.44	0.4	0.25	0.3	0.37	25	25	25	25	25	25	25
4:30	0.53	0.5	0.5	0.62	0.52	0.74	0.57	24.7	24.7	24.7	24.7	24.7	24.7	24.7
5:00	0.4	0.41	0.39	0.45	0.45	0.53	0.44	24.7	24.7	24.7	24.7	24.7	24.7	24.7
5:30	0.53	0.49	0.48	0.4	0.65	0.62	0.53	24.7	24.7	24.7	24.7	24.7	24.7	24.7
6:00	0.45	0.43	0.51	0.47	0.52	0.45	0.47	24.7	24.7	24.7	24.7	24.7	24.7	24.7
6:30	0.3	0.4	0.41	0.35	0.35	0.25	0.34	24.5	24.5	24.5	24.5	24.5	24.5	24.5
7:00	0.4	0.45	0.37	0.58	0.55	0.64	0.50	24	24	24	24	24	24	24
7:30	0.35	0.45	0.47	0.62	0.62	0.49	0.50	24.5	24.5	24.5	24.5	24.5	24.5	24.5
8:00	0.36	0.35	0.3	0.65	0.65	0.68	0.50	24.9	24.9	24.9	24.9	24.9	24.9	24.9
							0.64							27.1

APPENDIX E Data velocity and temperature class 3 Arif (second floor)

3 Arif	Velocity							Temperature						
Time	D1	D2	W1	W2	W3	W4	Average	D1	D2	W1	W2	W3	W4	Average
8:00	0.93	2.75	0.71	1.36	1.43	1.43	1.44	27.5	27.5	27.5	27.5	27.5	27.5	27.5
8:30	0.97	2.76	0.64	1.41	1.41	1.41	1.43	27.7	27.7	27.7	27.7	27.7	27.7	27.7
9:00	1.58	2.78	1.53	3.41	3.41	3.41	2.69	27.8	27.8	27.8	27.8	27.8	27.8	27.8
9:30	1.73	2.85	1.73	4.62	4.36	4.36	3.28	28.5	28.5	28.5	28.5	28.5	28.5	28.5
10:00	0.92	2.79	1.02	4.57	4.21	4.21	2.95	27.9	27.9	27.9	27.9	27.9	27.9	27.9
10:30	0.95	0.85	0.48	3.98	3.75	4.1	2.35	27.9	27.9	27.9	27.9	27.9	27.9	27.9
11:00	0.88	0.47	0.98	3.78	3.57	4.2	2.31	27.9	27.9	27.9	27.9	27.9	27.9	27.9
11:30	0.84	0.94	0.74	3.55	3.85	2.98	2.15	28.1	28.1	28.1	28.1	28.1	28.1	28.1
12:00	0.97	1.2	0.78	3.78	3.41	3.1	2.21	30.1	30.1	30.1	30.1	30.1	30.1	30.1
12:30	0.87	0.99	0.78	4.21	2.95	3.22	2.17	30.1	30.1	30.1	30.1	30.1	30.1	30.1
13:00	1.45	1.05	1.31	4.31	3.01	2.98	2.35	30.5	30.5	30.5	30.5	30.5	30.5	30.5
13:30	0.95	0.87	0.68	3.57	3.01	3.45	2.09	30.9	30.9	30.9	30.9	30.9	30.9	30.9
14:00	0.25	0.78	0.45	3.21	2.95	3.21	1.81	31	31	31	31	31	31	31
14:30	1.45	1.24	0.58	2.95	3.21	3.25	2.11	31.1	31.1	31.1	31.1	31.1	31.1	31.1
15:00	1.48	0.25	0.44	3.45	3.25	3.44	2.05	31.2	31.2	31.2	31.2	31.2	31.2	31.2
15:30	1.25	1.24	0.95	3.21	3.14	3.14	2.16	29.7	29.7	29.7	29.7	29.7	29.7	29.7
16:00	1.25	1.45	1.24	3.33	3.14	2.97	2.23	29.2	29.2	29.2	29.2	29.2	29.2	29.2
16:30	0.75	0.65	0.75	3.51	2.41	2.24	1.72	29.1	29.1	29.1	29.1	29.1	29.1	29.1
17:00	0.57	0.87	0.65	4.24	2.51	4.21	2.18	29	29	29	29	29	29	29
17:30	0.78	0.94	0.47	3.21	3.41	4.21	2.17	29	29	29	29	29	29	29
18:00	0.85	0.74	0.57	3.01	2.95	3.51	1.94	28.8	28.8	28.8	28.8	28.8	28.8	28.8
18:30	0.75	0.55	0.65	2.85	2.44	2.41	1.61	27.9	27.9	27.9	27.9	27.9	27.9	27.9
19:00	0.45	0.5	0.6	1.21	1.41	1.4	0.93	27.5	27.5	27.5	27.5	27.5	27.5	27.5
19:30	0.53	0.58	0.58	1.35	1.32	1.3	0.94	27.3	27.3	27.3	27.3	27.3	27.3	27.3
20:00	0.45	0.54	0.56	1.05	1.05	0.95	0.77	27	27	27	27	27	27	27
20:30	0.54	0.45	0.65	0.95	1.14	0.85	0.76	27	27	27	27	27	27	27
21:00	0.45	0.5	0.45	0.75	0.98	1.3	0.74	26.3	26.3	26.3	26.3	26.3	26.3	26.3
21:30	0.4	0.45	0.47	0.95	0.74	0.84	0.64	26.1	26.1	26.1	26.1	26.1	26.1	26.1
22:00	0.35	0.42	0.48	0.98	0.87	0.44	0.59	26.3	26.3	26.3	26.3	26.3	26.3	26.3
22:30	0.48	0.45	0.57	1.24	0.62	0.45	0.64	26.3	26.3	26.3	26.3	26.3	26.3	26.3
23:00	0.45	0.45	0.54	0.95	0.74	0.88	0.67	26.2	26.2	26.2	26.2	26.2	26.2	26.2
23:30	0.45	0.25	0.47	0.84	1.24	0.47	0.62	26.2	26.2	26.2	26.2	26.2	26.2	26.2
0:00:00	0.44	0.45	0.25	0.84	1.45	0.87	0.72	26	26	26	26	26	26	26
0:30:00	0.44	0.35	0.25	0.75	0.58	0.65	0.50	25	25	25	25	25	25	25
1:00	0.45	0.42	0.42	0.68	0.75	0.6	0.55	25	25	25	25	25	25	25
1:30	0.52	0.45	0.54	0.57	0.45	0.65	0.53	25	25	25	25	25	25	25
2:00	0.48	0.49	0.48	0.85	0.65	0.65	0.60	25	25	25	25	25	25	25
2:30	0.45	0.25	0.45	0.95	0.87	0.85	0.64	25	25	25	25	25	25	25
3:00	0.25	0.45	0.45	0.75	0.65	0.45	0.50	25	25	25	25	25	25	25
3:30	0.74	0.15	0.35	0.84	0.65	0.75	0.58	25.1	25.1	25.1	25.1	25.1	25.1	25.1
4:00	0.47	0.44	0.45	1.03	0.84	0.75	0.66	25	25	25	25	25	25	25
4:30	0.65	0.45	0.48	0.85	0.52	0.67	0.60	24.9	24.9	24.9	24.9	24.9	24.9	24.9
5:00	0.25	0.35	0.28	0.87	0.75	0.84	0.56	24.9	24.9	24.9	24.9	24.9	24.9	24.9
5:30	0.44	0.48	0.53	0.64	0.58	0.65	0.55	24.9	24.9	24.9	24.9	24.9	24.9	24.9
6:00	0.48	0.45	0.41	0.5	0.64	0.67	0.53	24.7	24.7	24.7	24.7	24.7	24.7	24.7
6:30	0.41	0.41	0.45	0.75	0.24	0.56	0.47	24.5	24.5	24.5	24.5	24.5	24.5	24.5
7:00	0.87	0.75	0.97	0.75	0.54	0.65	0.76	24	24	24	24	24	24	24
7:30	0.95	0.84	0.47	1.09	0.98	0.78	0.85	24.5	24.5	24.5	24.5	24.5	24.5	24.5
8:00	0.84	0.42	0.85	1.25	1.24	0.98	0.93	25	25	25	25	25	25	25
							1.33							27.2

APPENDIX F Datasheet

Name:____ Date:________________

Site name:____

Building type:____

W = Window
D = Door
T = Tent

Building size	
Building area	
Floor level	
Inlet (Exp= W1, W2)	
Outlet (Exp= W3, W4)	
Ceiling material	
Floor material	
Wall material	
Position of opening	

Tent Brand		Window quantity	
Tent type		Door quantity	
Tent size		Lamp quantity	
Tent quantity		Fan quantity	

APPENDIX F (Cont.) Datasheet

Window number:____________ Window type:_________________

Width	
Height	
Window sill	
Height of the window from the floor	

Window number:____________ Window type:_________________

Width	
Height	
Window sill	
Height of the window from the floor	

APPENDIX F (Cont.) Datasheet

Window number:____________

Time	Velocity (m/s)	Temperature (°C)	Note
00:00			
01:00			
02:00			
03:00			
04:00			
05:00			
06:00			
07:00			
08:00			
09:00			
10:00			
11:00			
12:00			
13:00			
14:00			
15:00			
16:00			
17:00			
18:00			
19:00			
20:00			
21:00			
22:00			
24:00			

Comment:

APPENDIX G Approval letter from eRAS

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

TEL : 0388846591
FAKS : 0388846579

Ruj. Kami : KPM.600-3/2/3-eras(11418)
Tarikh : 29 November 2021

OOI QI XIANG
NO. KP : 951109085081

6, JALAN SCI 3/17,
TAMAN GARDEN VILLA, 31150 ULU KINTA
PERAK

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN :
KERJA PENYELIDIKAN TENTANG KUALITI UDARA DAN ALIRAN UDARA DI SEKOLAH YANG MENJADI PUSAT PERMINDAHAN BANJIR NEGERI MELAKA

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti di bawah telah diluluskan dengan syarat :

" KELULUSAN INI BERGANTUNG KEPADA KEBENARAN PENGARAH JPN DAN PERTIMBANGAN PENTADBIR SEKOLAH. PEMASANGAN ALAT TIDAK BOLEH MENGGANGGU STRUKTUR BANGUNAN. "

3. Kelulusan adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **30 November 2021** hingga **11 Mei 2022**

5. Tuan dikehendaki menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat pdf dalam CD kepada Bahagian ini.Tuan juga diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak diterbitkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Ketua Penolong Pengarah Kanan
Sektor Penyelidikan dan Penilaian Dasar
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

salinan kepada:-

JABATAN PENDIDIKAN MELAKA

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

APPENDIX H Approval letter from Melaka State Education Department

JABATAN PENDIDIKAN MELAKA,
JALAN ISTANA,
PETI SURAT NO.62,
75450 MELAKA.

Pengarah : 06-2323782
Timbalan : 06-2323781
Pejabat Am : 06-2323777
06-2323778
06-2323779
Peperiksaan : 06-2323780
Faks : 06-2320500
Laman Web : www.moe.gov.my/jpnmelaka

Ruj. Kami : JPNM.SPS.MT6.600 -11/1/1Jld.3(48)
Tarikh : 02 Disember 2021

1. **Ooi Qi Xiang (M042010044)**
2. **Mohamad Asraf Aidee bin Mohd Baseri (B091810017)**
3. **Muhammad Nazirul bin Hassan Basri (B091810103)**

Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka.

Tuan,

KEBENARAN MENJALANKAN PENYELIDIKAN

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa Jabatan Pendidikan Negeri Melaka tiada halangan bagi pihak tuan untuk menjalankan kajian yang bertajuk;

" PENYELIDIKAN TENTANG KUALITI UDARA DAN ALIRAN UDARA DI SEKOLAH YANG MENJADI PUSAT PEMINDAHAN BANJIR NEGERI MELAKA" diluluskan.

3. Dimaklumkan juga di sini bahawa kajian ini adalah semata-mata untuk memenuhi syarat kursus yang diduduki sahaja dan bukan untuk tujuan lain. Dan pihak tuan diminta untuk mematuhi **"Standard Operation** Procedure (SOP)" yang telah ditetapkan oleh **Majlis Keselamatan Negara (MKN).** Borang atau data soal selidik perlu dibuat secara dalam talian.

4. Surat kelulusan ini sah digunakan bermula **30 November 2021 hingga 11 Mei 2022.**

5. Walau bagaimanapun, pihak tuan adalah dinasihatkan menghubungi pihak Pengetua/ Guru Besar sekolah terlebih dahulu untuk berbincang dan mendapatkan persetujuan. Sebarang pertanyaan, sila hubungi **Encik Azli bin Musalleh, Penolong Pengarah Unit Sekolah Menengah, dan Tingkatan 6** di talian **06-2322459.**

Sekian, terima kasih.

"WAWASAN KEMAKMURAN NEGARA 2030"
"MELAKAKU MAJU JAYA, RAKYAT BAHAGIA, MENGGAMIT DUNIA"
"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(HAJI KARIM BIN TUMIN)
Timbalan Pengarah Pendidikan,
Sektor Pengurusan Sekolah,
b.p Pengarah Pendidikan Negeri Melaka,

"Pendidikan Berkualiti, Insan Terdidik, Negara Sejahtera"
#jpnmelakajenamakerajaannombor1
(Sila catatkan rujukan Jabatan ini apabila berhubung)

APPENDIX I Temporary tent loan application letter

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka, Malaysia.

+606 270 1000
+606 270 1022
www.utem.edu.my

FAKULTI TEKNOLOGI KEJURUTERAAN MEKANIKAL DAN PEMBUATAN
Tel : +606 270 1184 | Faks : +606 270 1068

Rujukan Kami (Our Ref) : UTeM.46.01/400-22/1 (36)
Rujukan Tuan (Your Ref) :
Tarikh (Date) : 13 Disember 2021

Pn Noor Azimah binti Ahmad Baharom,
Pengarah,
Pejabat Kebajikan Masyarakat Daerah Melaka,
36-1, Jln Kc 2, Kota Cemerlang,
75450 Melaka Malaysia.

Puan,

PERMOHONAN PEMINJAMAN KHEMAH SEMENTARA BAGI MENJALANKAN KERJA PENYELIDIKAN TENTANG KUALITI UDARA DAN ALIRAN UDARA DI PUSAT PEMINDAHAN BANJIR NEGERI MELAKA

Merujuk kepada perkara di atas, saya Ts. Dr. Amir Abdullah Bin Muhamad Damanhuri merupakan pensyarah di Fakulti Teknologi Kejuteraan Mekanikal dan Pembuatan (FTKMP), UTeM. Bidang kajian saya menjurus kepada aliran udara, keselesaan terma dan kualiti udara.

2. Oleh yang demikian, pihak saya telah mendapat tajaan geran dari pihak universiti untuk menjalankan penyelidikan berkaitan aliran udara dan keselesaan terma di pusat pemindahan banjir sementara di kawasan Melaka. Saya dengan rendah diri ingin memohon bantuan dan sokongan dari pihak PKMD, Melaka bagi menyelesaikan projek penyelidikan ini.

3. Menurut perbincangan dengan wakil JKM sebelum ini, kami dimaklumkan pusat pemindahan banjir di Melaka adalah bersifat sementara dan kebiasaannya di dewan serbaguna dan bangunan sekolah. Oleh itu, kami berharap pihak PKMD dapat membantu kami dari segi:

i. Peminjaman khemah sementara ketika proses pengumpulan data bagi tujuan simulasi.

4. Untuk makluman tuan juga, beberapa pelajar saya iaitu pelajar ijazah sarjana dan ijazah sarjana muda juga akan terlibat secara terus ketika proses pengumpulan data. Bagi tujuan ini, pihak kami berjanji akan menjaga nama baik fakulti, universiti dan pihak sekolah ketika proses penyelidakan dijalankan. Segala SOP dan syarat vaksin juga akan dipatuhi dengan baik. Senarai nama pelajar yang terlibat adalah seperti di bawah:

No	Nama	Matriks	Program	No. Telefon	Tajuk Kajian
1	Ooi Qi Xiang	M042010044	Sarjana	016-5642684	Thermal Comfort Level & Air-flow Distribution for Flood Evacuation Centres in Tropical Climate Region
2	Mohamad Asyraf Aidee Bin Mohd Baseri	B091810017	Sarjana Muda	010-2044282	Air flow distribution in evacuation centre in tropical climate region
3	Muhammad Nazirul Bin Hassan Basari	B091810103	Sarjana Muda	0 11-1944 5711	Investigation Of Thermal Comfort for Temporary Evacuation Centre In Tropical Climate At Melaka

APPENDIX I (cont.) Temporary tent loan application letter

Segala kerjasama daripada pihak tuan amat saya hargai. Saya boleh dihubungi secara terus dan sedia membantu bagi tujuan penerangan kepada pihak tuan. No telefon : 016-6573835, dan emel : amir.abdullah@utem.edu.my.

Sekian, terima kasih.

Ts. Dr. Amir Abdullah bin Muhamad Damanhuri,
Pensyarah/Penyelidik
Fakulti Teknologi Kejuteraan Mekanikal dan Pembuatan (FTKMP),
Universiti Teknikal Malaysia Melaka (UTeM),
Melaka